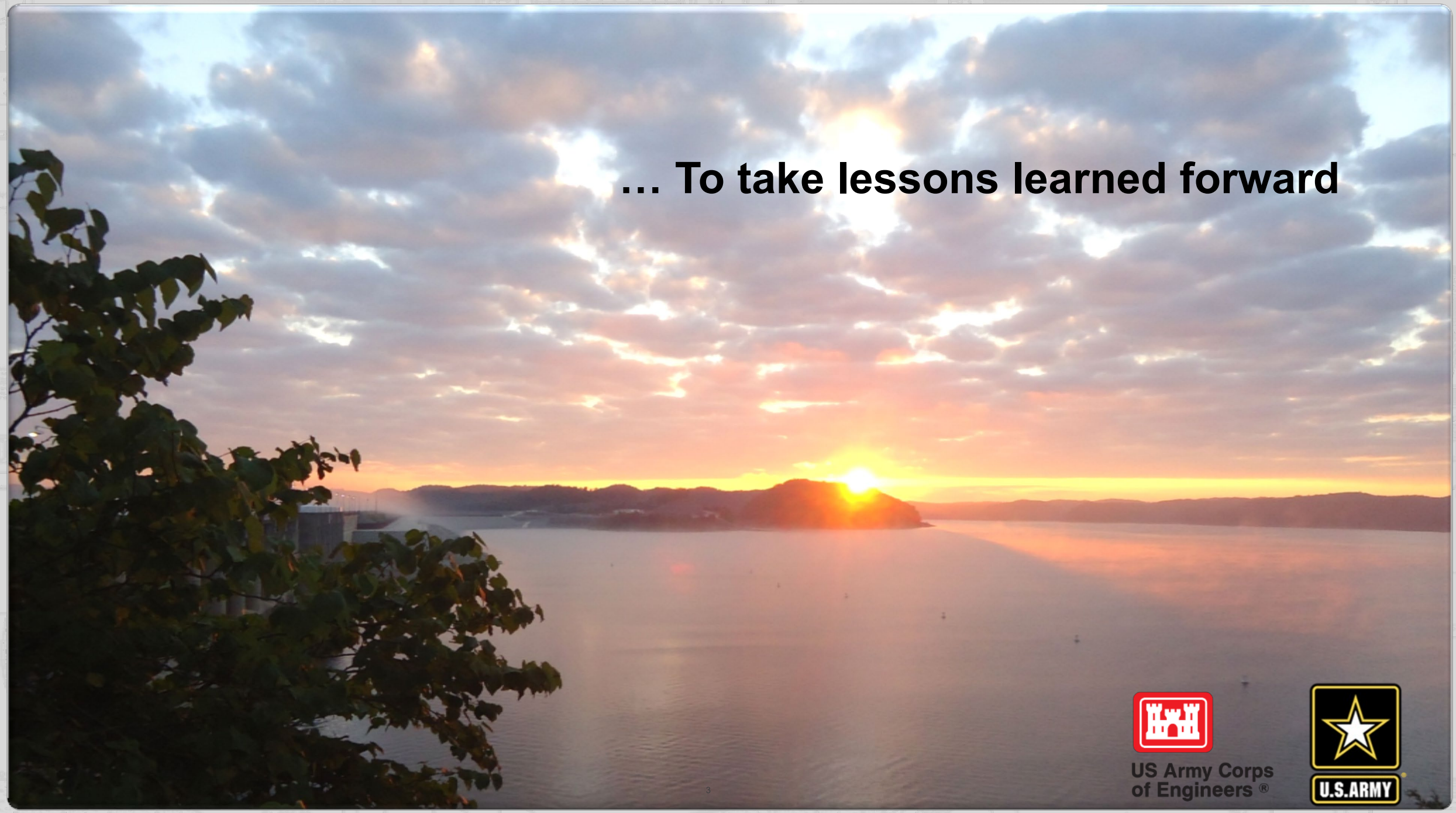
CONSTRUCTION DATA MANAGEMENT SYSTEMS AND LESSONS LEARNED

Vanessa C. Bateman, PE, PG, D.GE
Chief of Civil Works Engineering
Engineering and Construction,
HQUSACE

US Army Corps of Engineers ®


… To take lessons learned forward
US Army Corps
of Engineers ®
U.S.ARMY

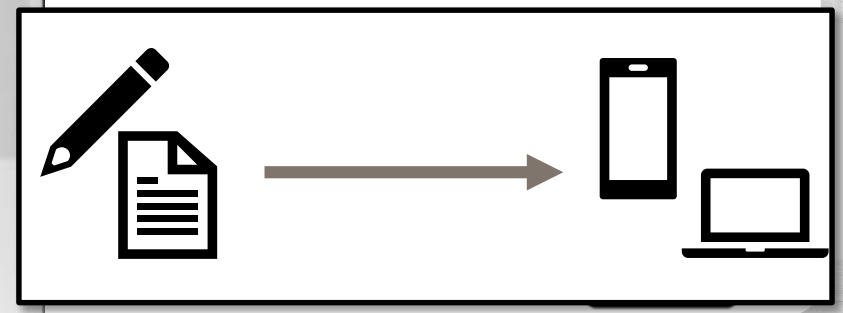
We have to understand the problem

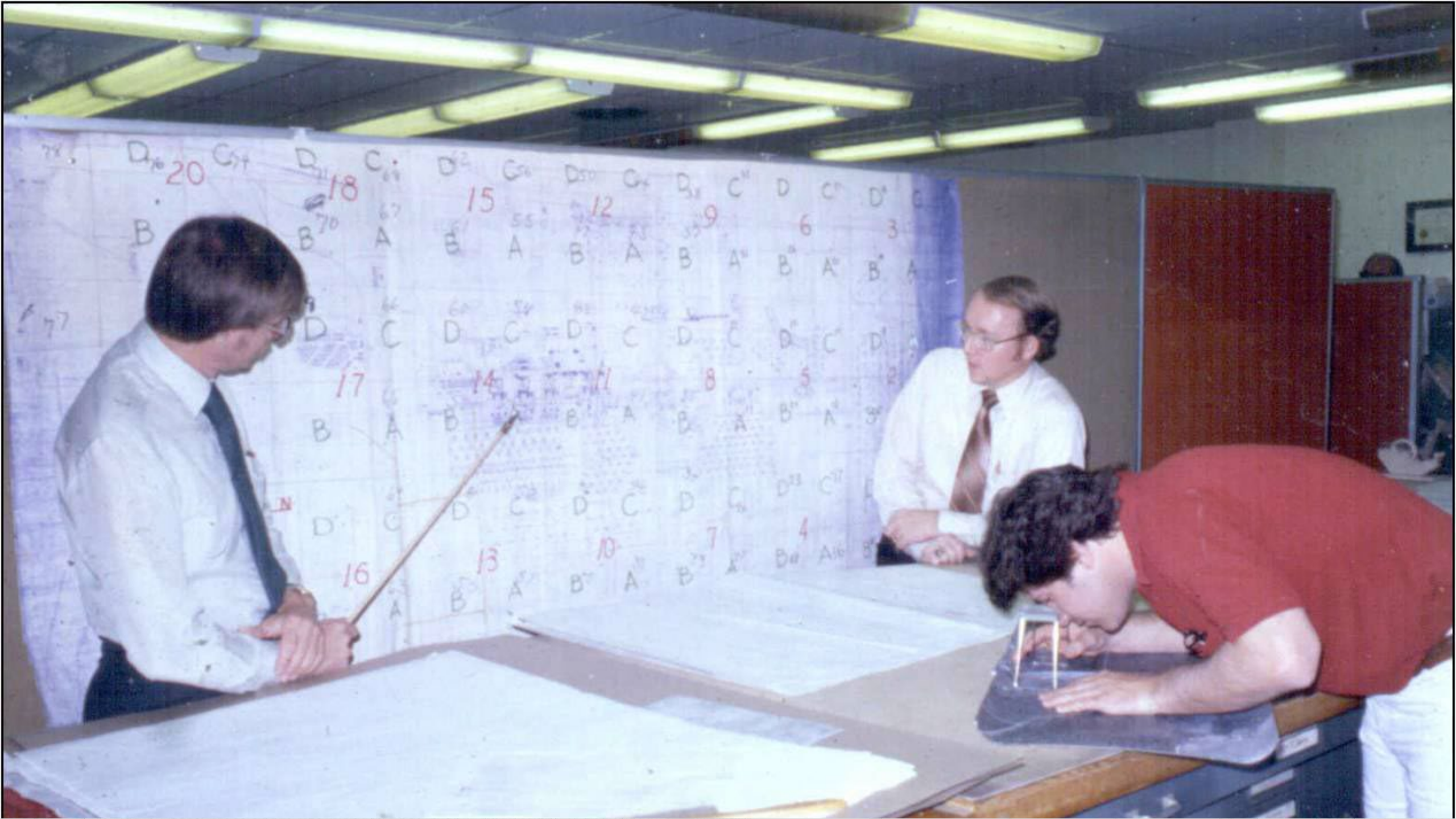
1957 – Computing Station

What's "missing" here?

M125 23 Oct 1957 Old Hickory Power Plant -
Index Test - Computing Station

Technology has radically changed our world





We forget sometimes, how fast things have changed

NIC Takes a Big Gulp of Water Control Data

Water Control was one of the first offices in the district to use the Internet. Rich Engstrom and Lance Klindt created a home page to revolutionize many day-to-day activities there.

Engstrom, the water control systems manager, and Klindt, a hydrologic technician, formerly used a miniframe computer to capture data collected from the more than 200 gage stations scattered throughout the district.

"Forecasters are on call 24-hours a day," Engstrom said. "Sometimes they would have to call from home, dial into the miniframe, and type computer commands. Forecasters were the only ones who could really access, interpret, and use the information on the miniframe."

A decision to phase out that system prompted Engstrom to suggest creating an Internet home page to replace it.

"I saw someone from another district demonstrate a home page. Investigating other home pages became exciting as we imagined how to improve our jobs."

Their system helps more than district forecasters. Formerly, customers outside the Corps would call by phone when they needed water levels. During the Great Flood of '93, an estimated 300 phone calls came in every day. Since customers are now using the Internet to find data, an average of 30 phone calls come in during flood events.

"We're starting to receive e-mail from people all over the country," Engstrom said. "The United States Geological Service and other agencies use our home page. I even had e-mail from some fishermen in Fairport, Iowa."

Lance Klindt checks latest water control data.

Both men see ease of use as a major advantage of their home page. Also, the information is nearly real time. Gage data is transmitted via satellite hourly to the water control center.

"Our biggest accomplishment is getting data available to the public that has meaning and is still current," Klindt said.

Story and photo by Denise Tyler

August 1996 Tower Times 7

Leveraging the internet and increased computer power

USACE – Rock Island District
1996

"I saw someone from another district demonstrate a home page. Investigating other home pages became exciting as we imagined how to improve our jobs."

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We have a LOT of data to compile and understand.

BECUASE of the improvements to our tools!

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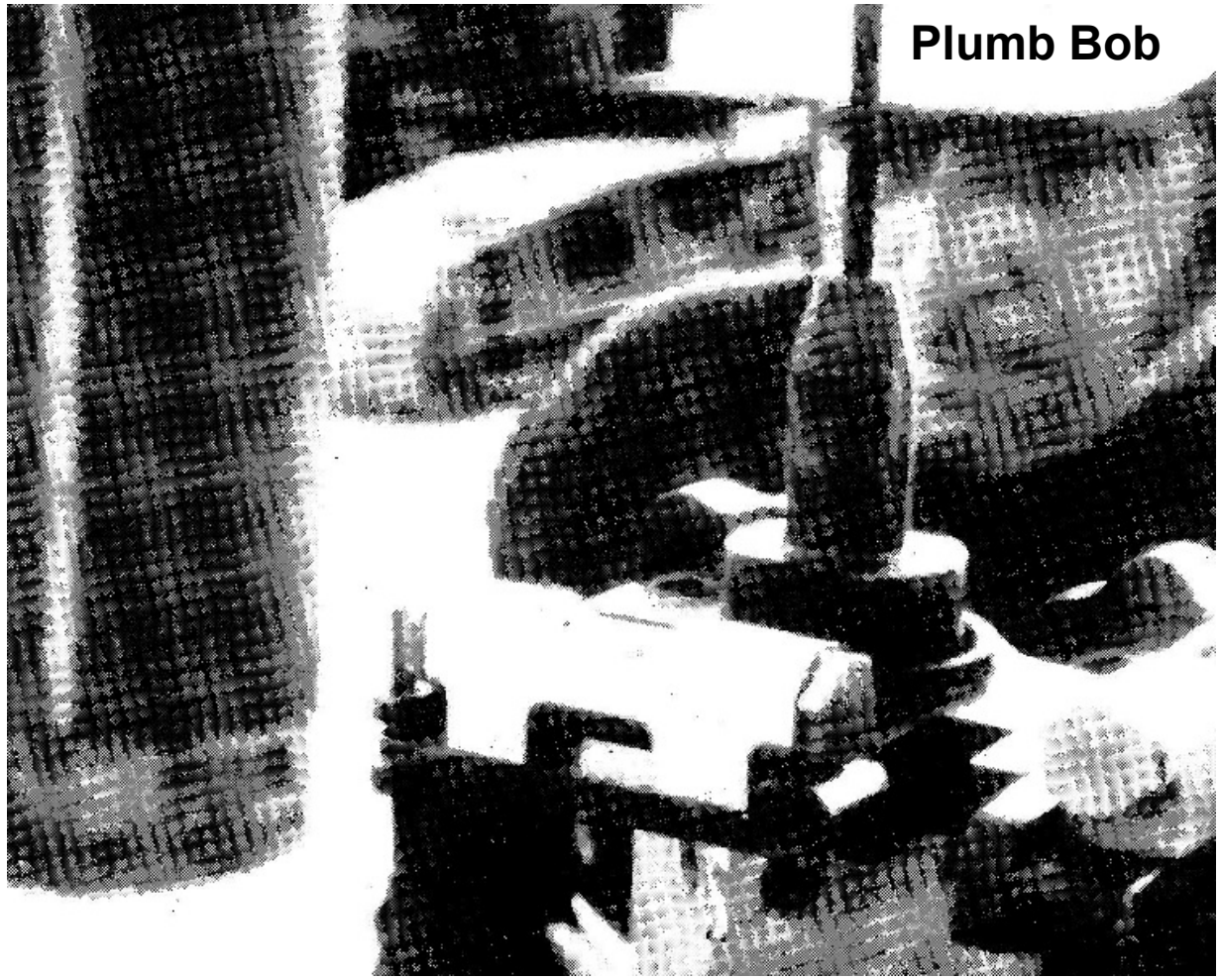
USACE Evolution

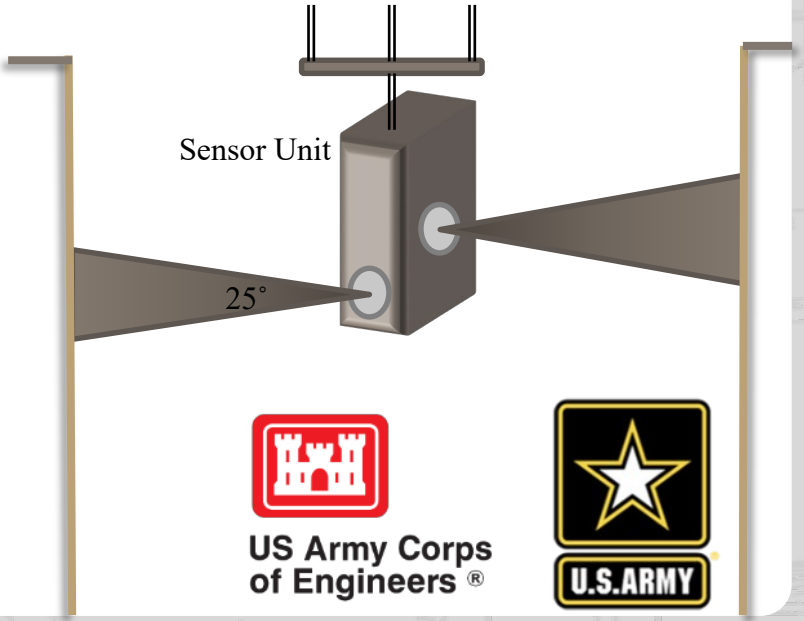
Verification Methods- Our tools have evolved



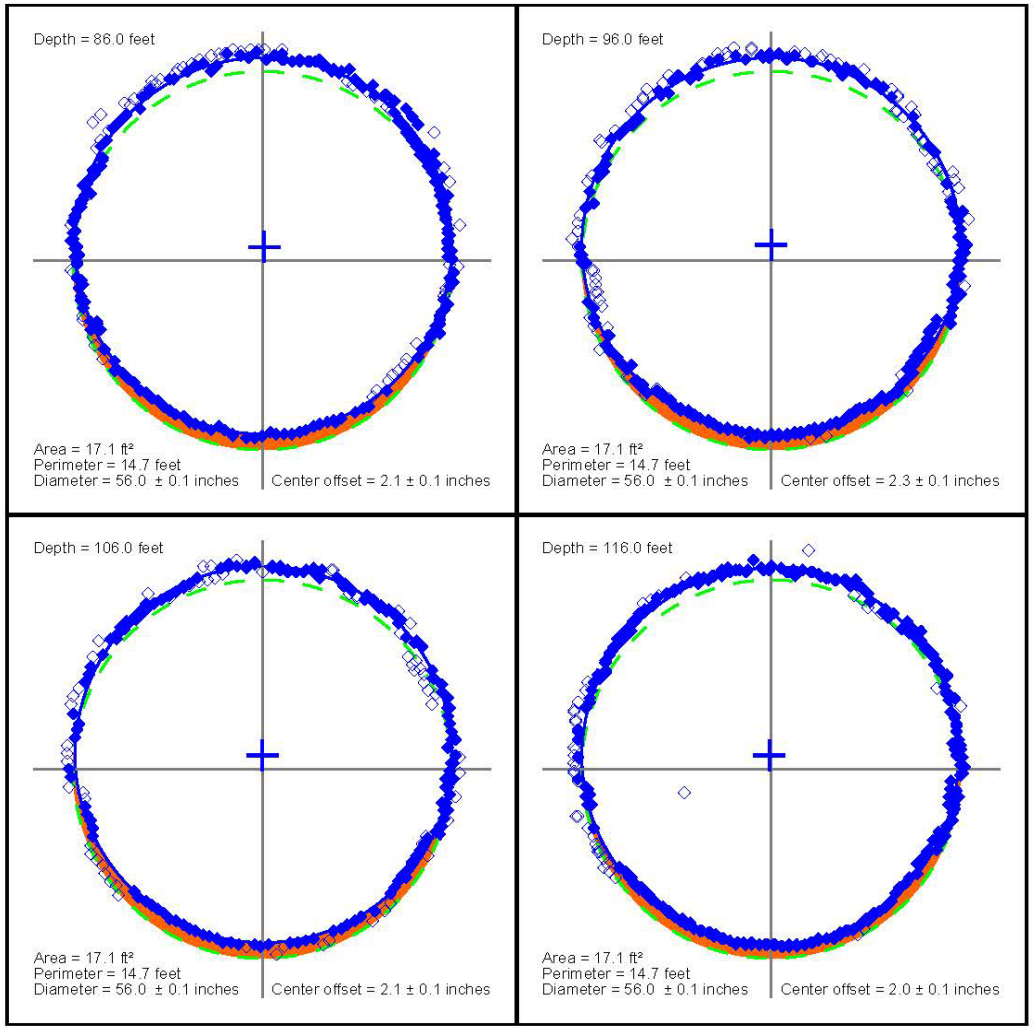
Plumb Bob

1970s Seepage Wall Element Verification

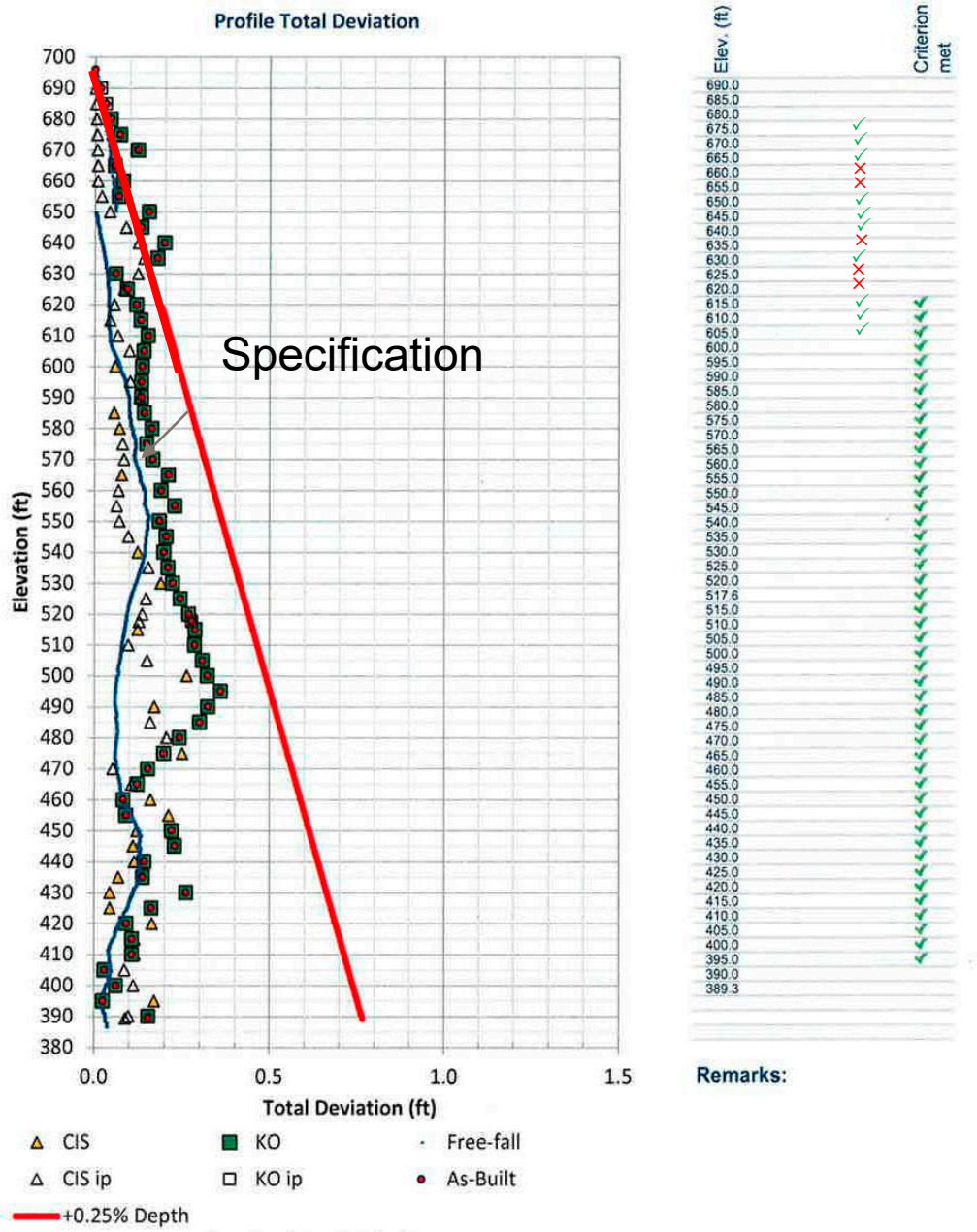
Today!



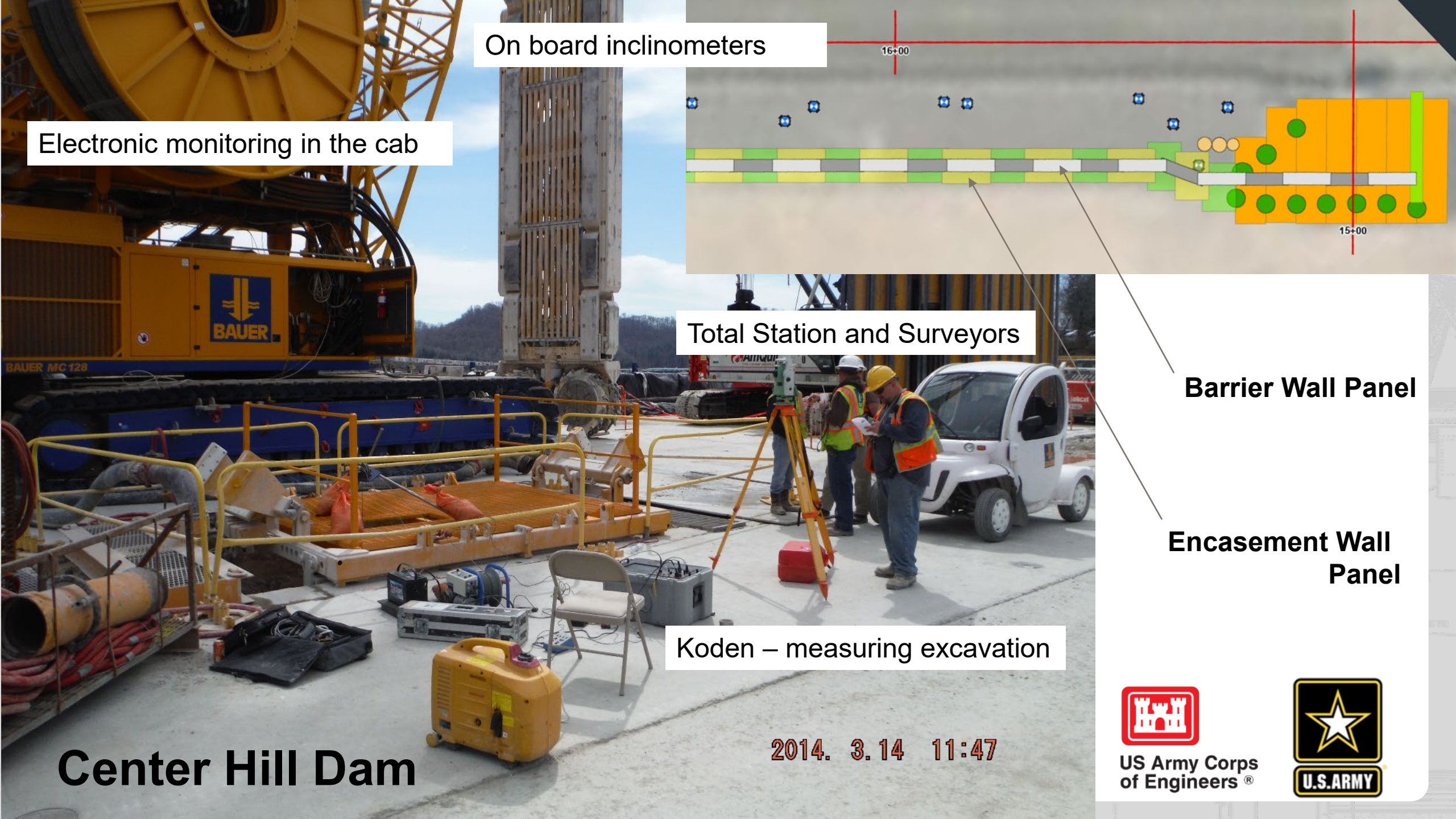
USACE Evolution
Verification Methods



And now we can easily measure and plot multiple methods



great…
r holes



Center Hill Dam

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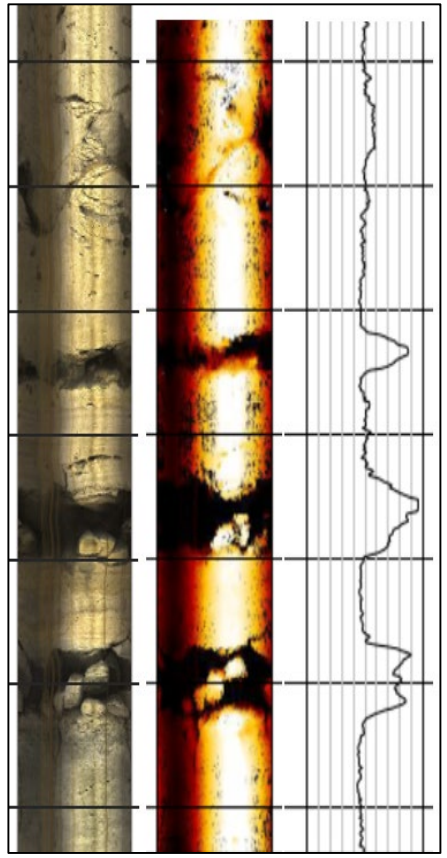
We are gathering data in so many new ways

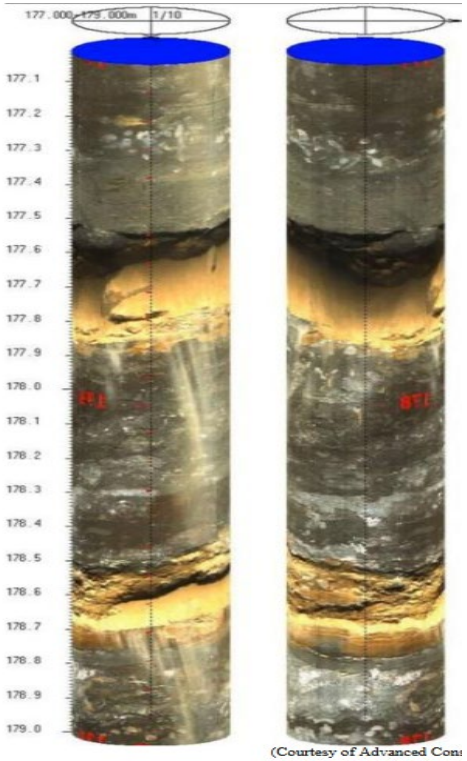
200208-A-BO243-1046

Brooke Hubbard, a civil engineer from the Unmanned Aerial Vehicle (UAV) section with the Jacksonville District explains technology used to U.S. Army Corps of Engineers' South Atlantic Division senior enlisted adviser Command Sgt. Maj. Chad C. Blansett during a recent visit Feb. 8, 2021. (USACE photo by Mark Rankin)



Mosul Dam

Wolf Creek



Optical Televiewer

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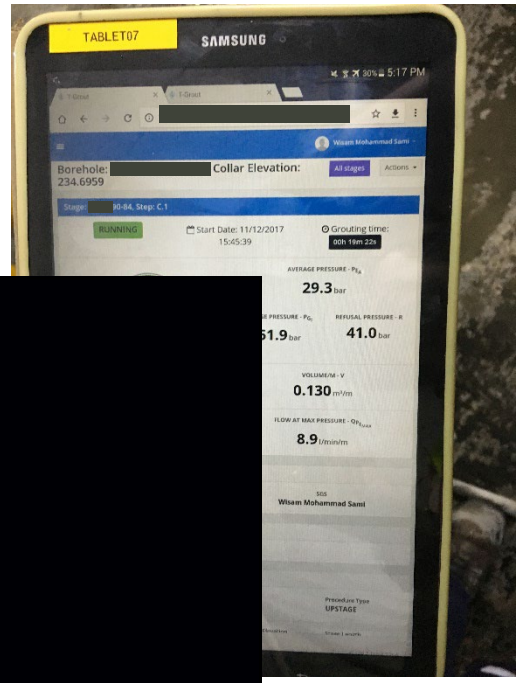
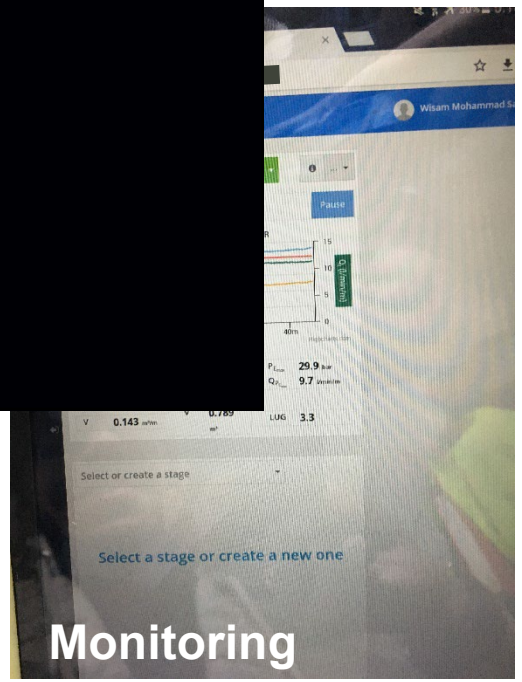
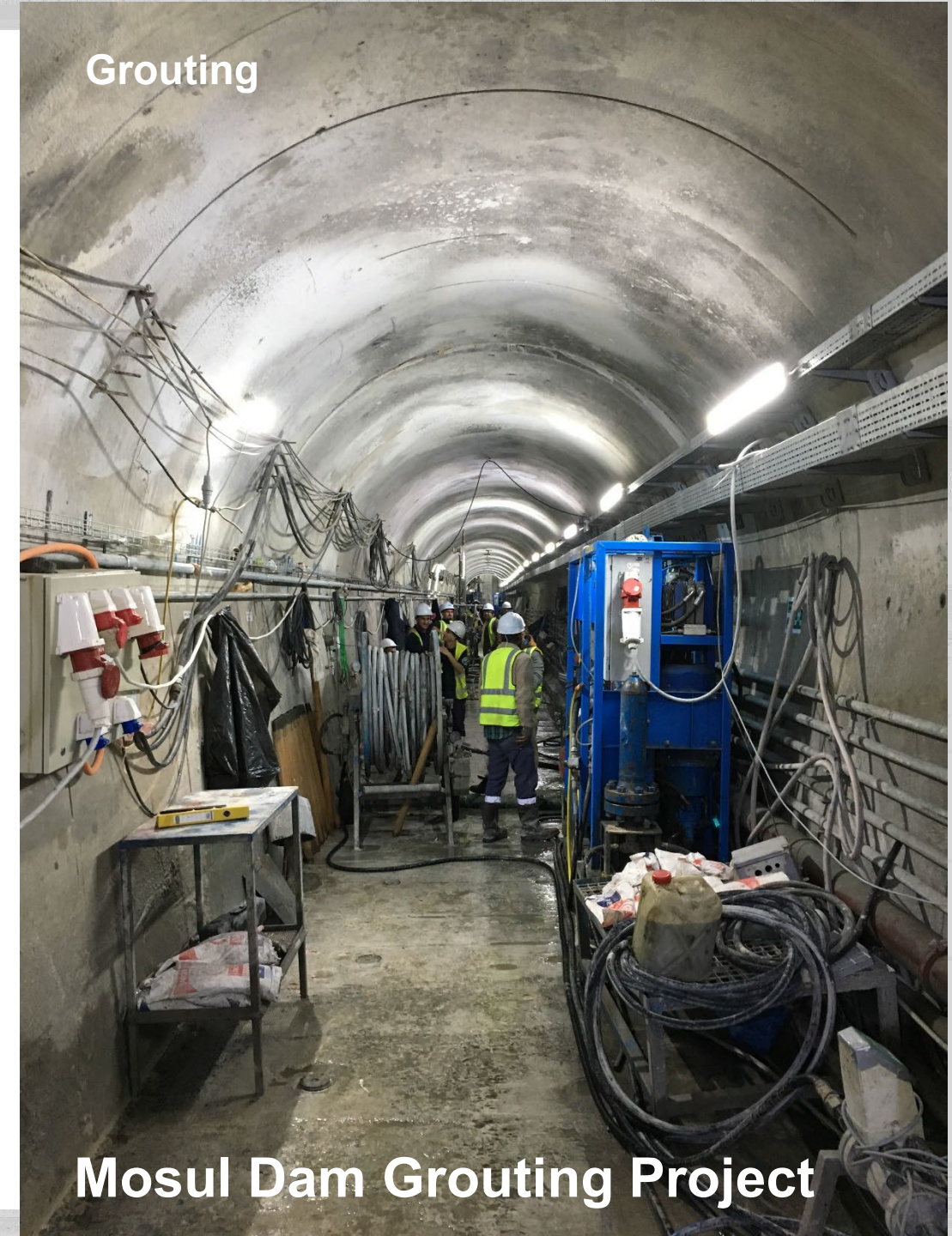
Drilling


TABLET07
SAMSUNG
Borehole:
Collar Elevation:
234.6959
Start Date: 11/12/2017
15:45:39
Grouting time:
00h 19m 22s
29.3 bar
41.0 bar
0.130
8.9
Wisam Mohammad Sami
UPSTAGE


Pause
Select or create a stage
Select a stage or create a new one
Monitoring


Grouting
Mosul Dam Grouting Project

LOTS!!!!
of Construction equipment comes with automated monitoring.

(Are you looking at that data?)

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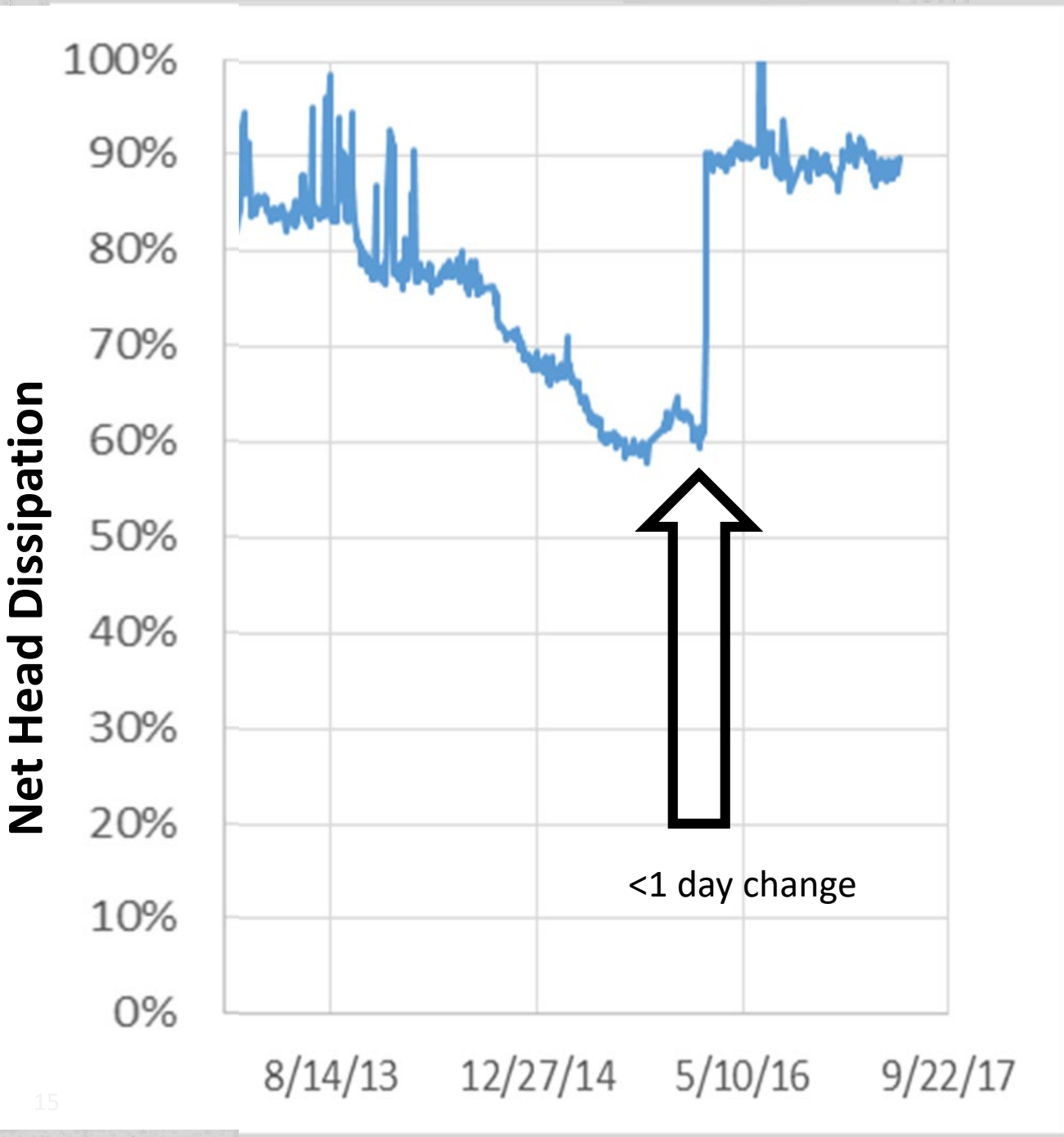
LIVE
Mosul Dam
We need information at the speed of relevance


Net Head Dissipation
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
8/14/13
12/27/14
5/10/16
9/22/17
<1 day change

If all these machines are making data – do you want to type it all in??

Do you want to copy duplicate data into your data tables?

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Wolf Creek Dam
We are generating a huge amount of data FAST
Are you Ready?

USACE Evolution
Changes in Data Management

+ 36 GB Files

Imagine Getting the data for all these instruments

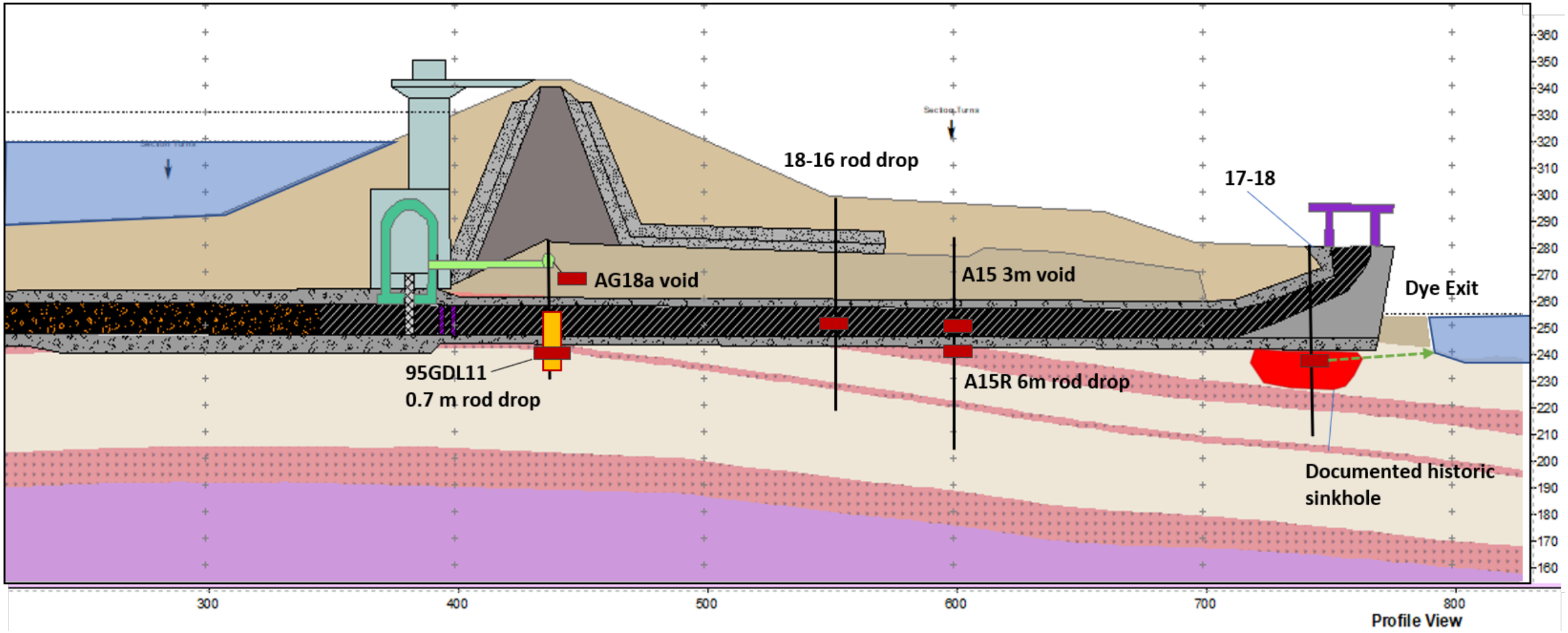
And all the construction data

- **4,850 holes** drilled & grouted to completion
- **348,652 m** length of drilling
- **39,227 m³ of grout** (22,177 tons of solids)
  - 1.3 Washington Monuments by Volume

- Pore Pressure Cells
- Earth Pressure Cells
- Teletensometers
- Extensometers
- Inclinometers
- Hanging Pendulums
- Accelerometers
- Manual Water Level Gauges
- Survey Monitoring Points
- Weirs

211 Gallery Piezometers

While Simultaneously building and updating the subsurface information – including still finding historical data



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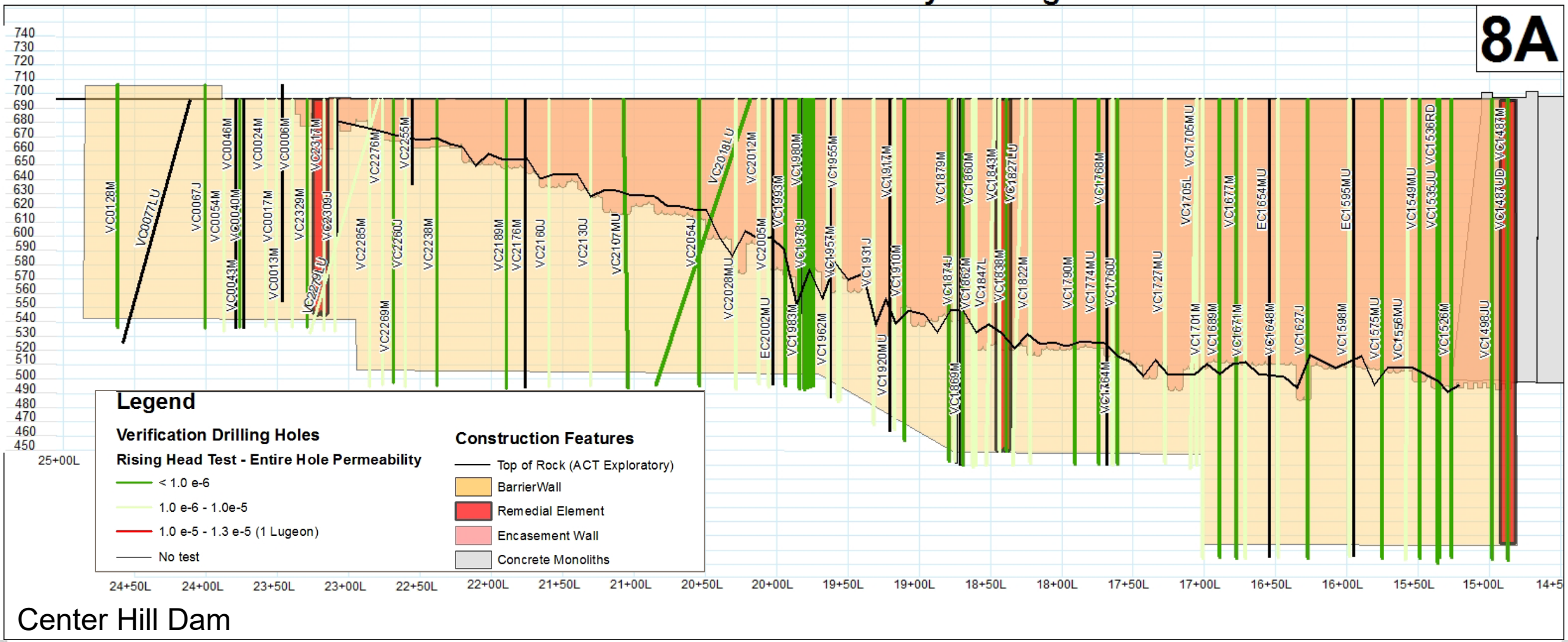
Verification Program - Permeability

Paper Map Printed: 2/15/2016

Barrier Wall Concrete Results - Verification Water Permeability Testing

8A



Center Hill Dam

And comparing all your verification testing with this data

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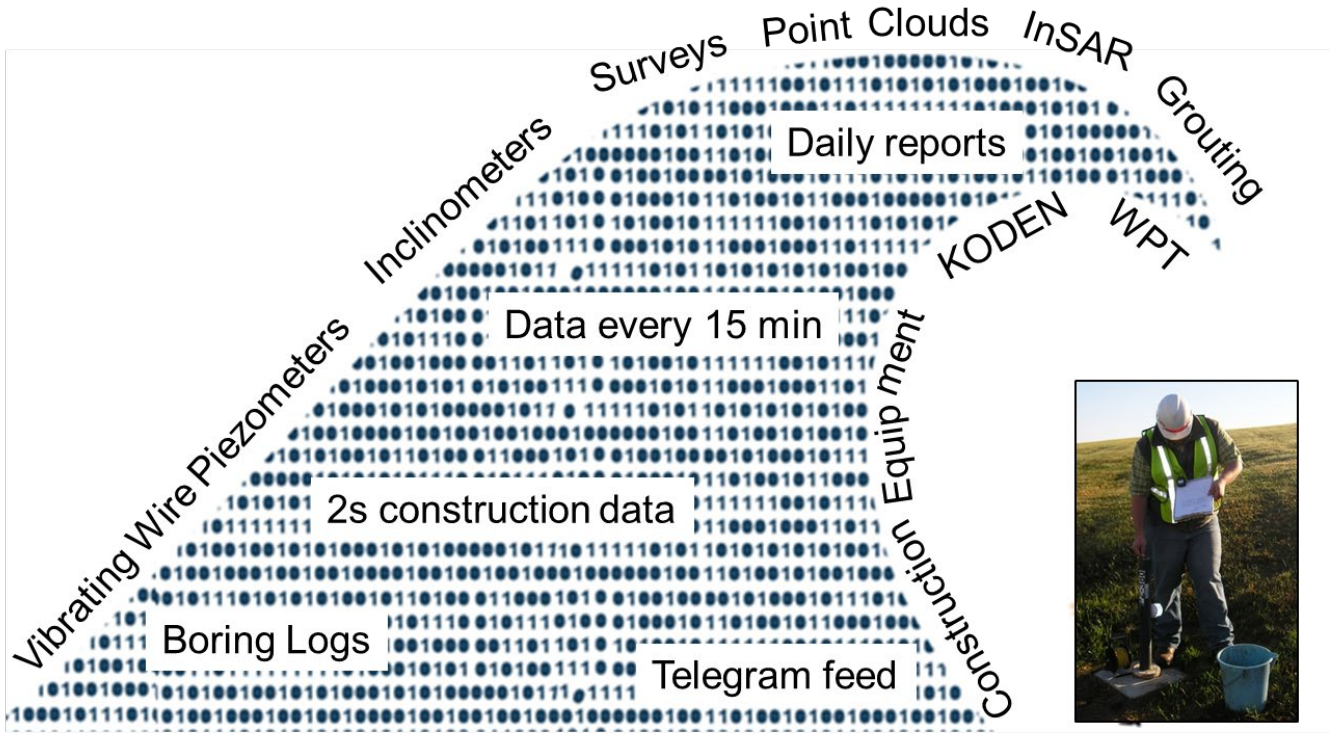
Finding the needle in the digital haystack!



Big Enough Data…

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So how do we do we solve the problem?

Figure out what data management system you are already using

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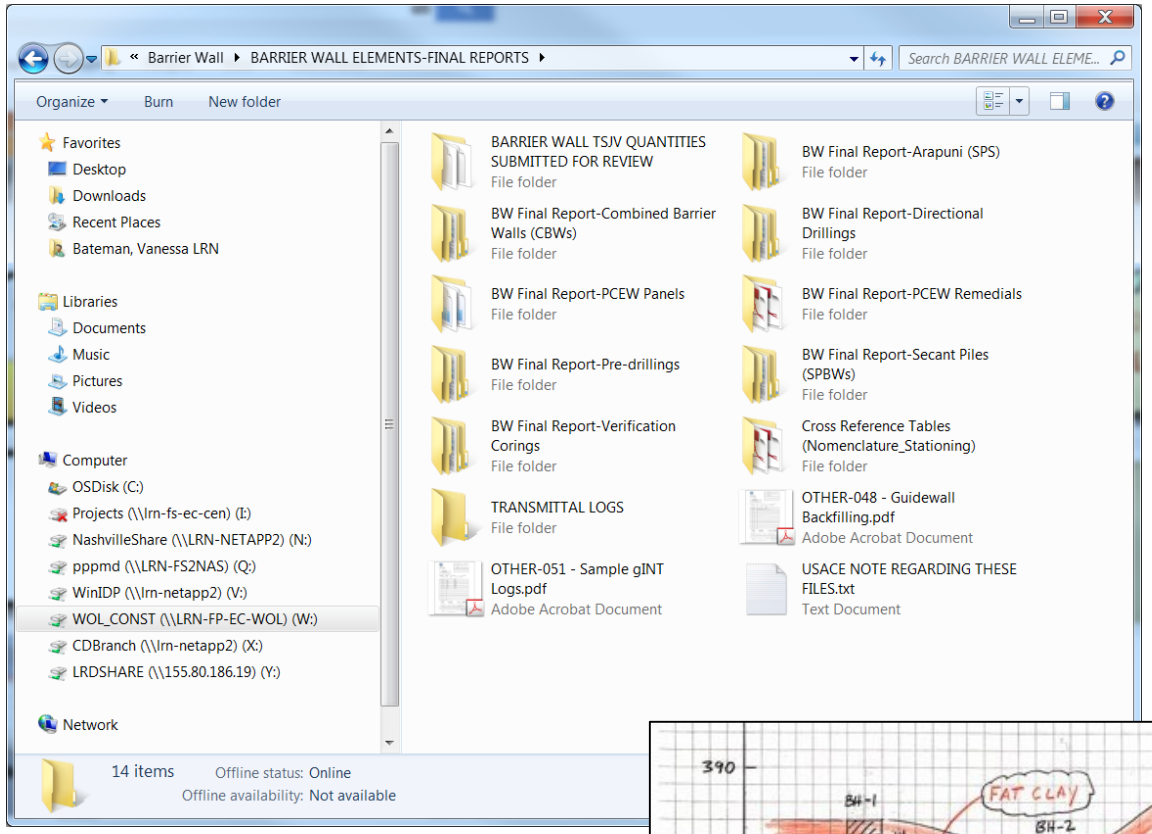
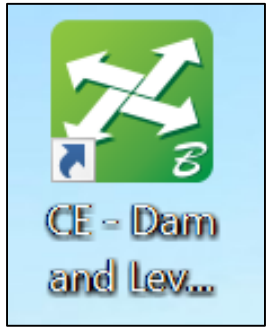
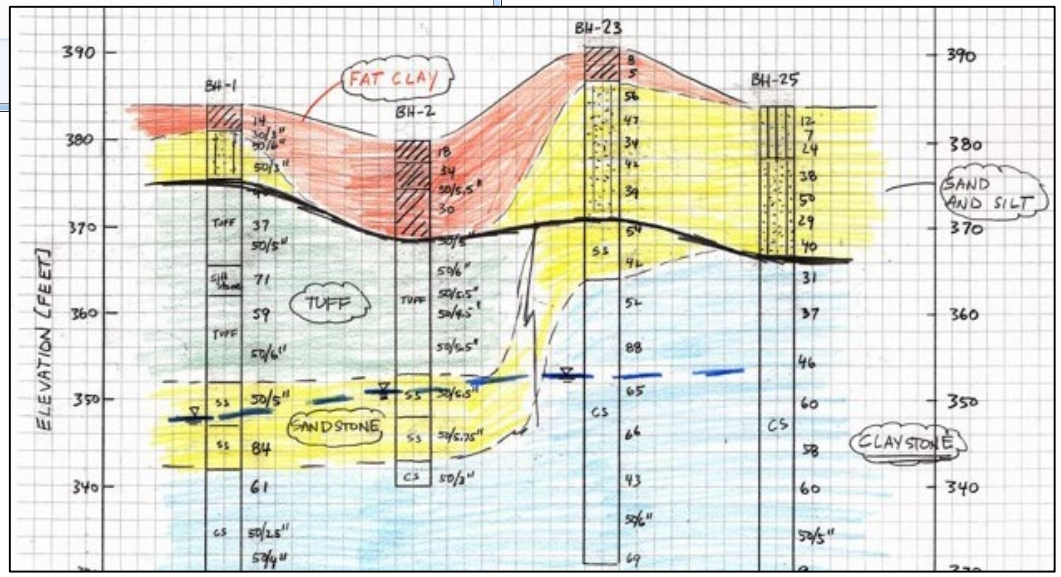


Find out what data you have already!





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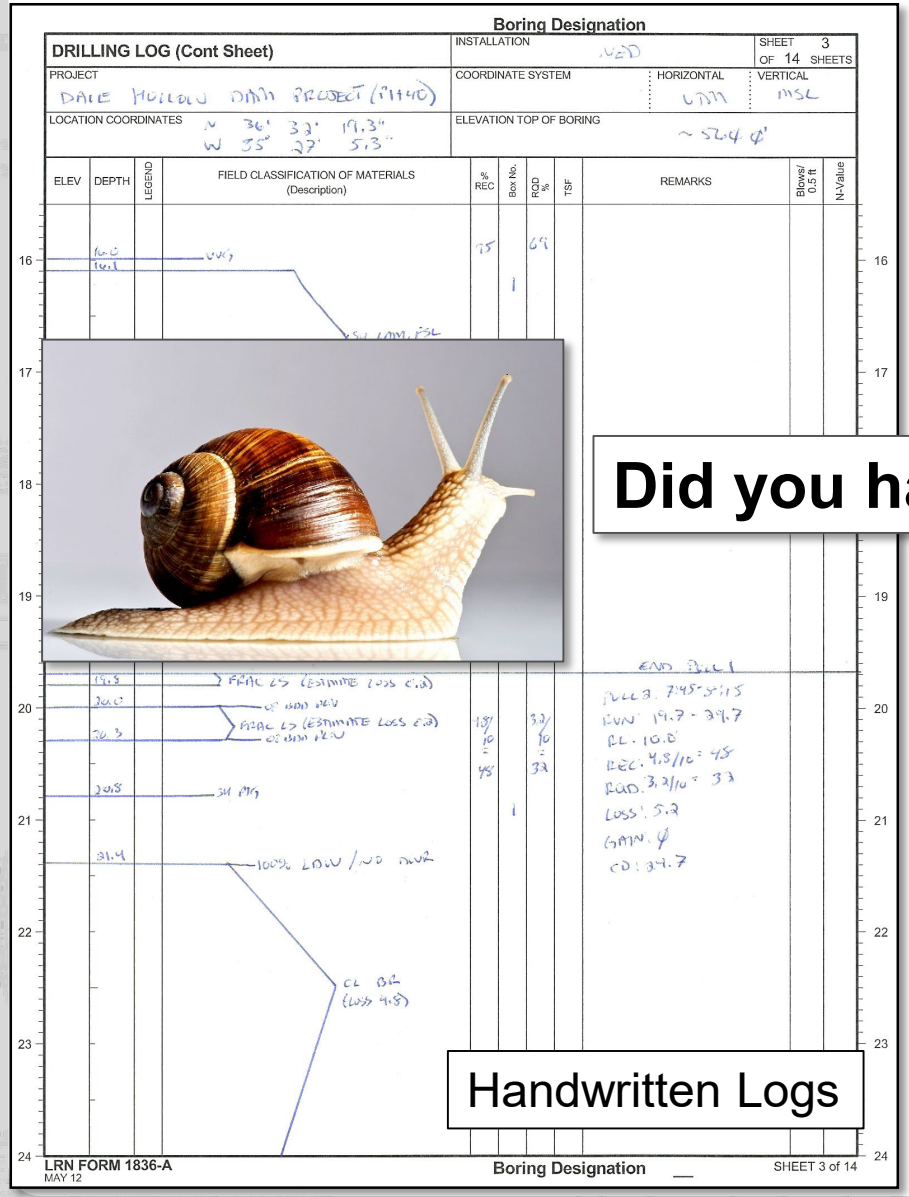
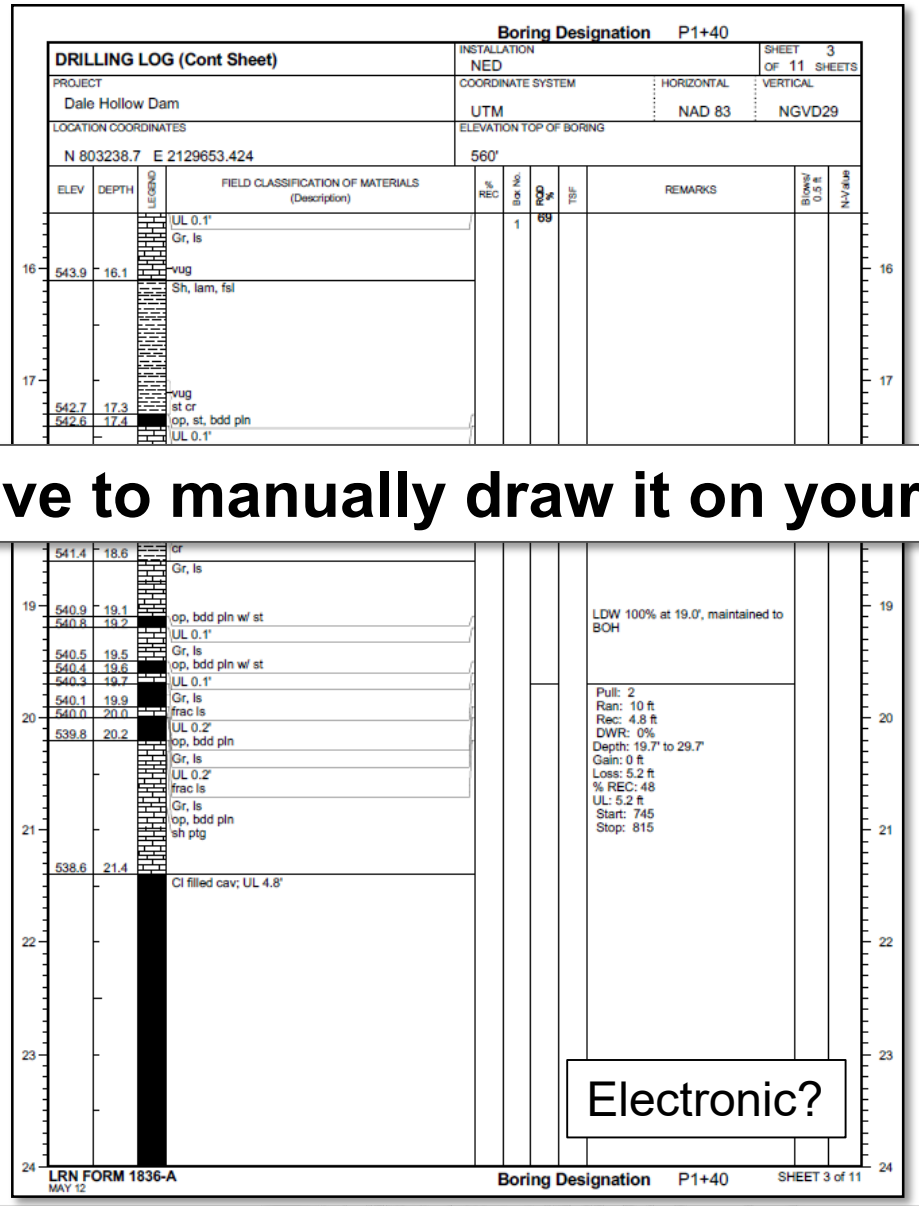
What's the format of your data?



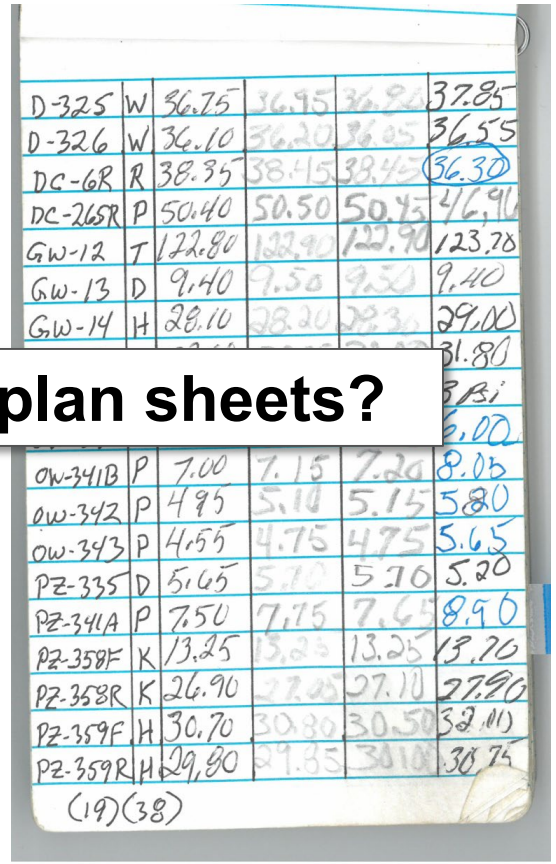
Handwritten Logs



Electronic?

Did you have to manually draw it on your plan sheets?

Field Books



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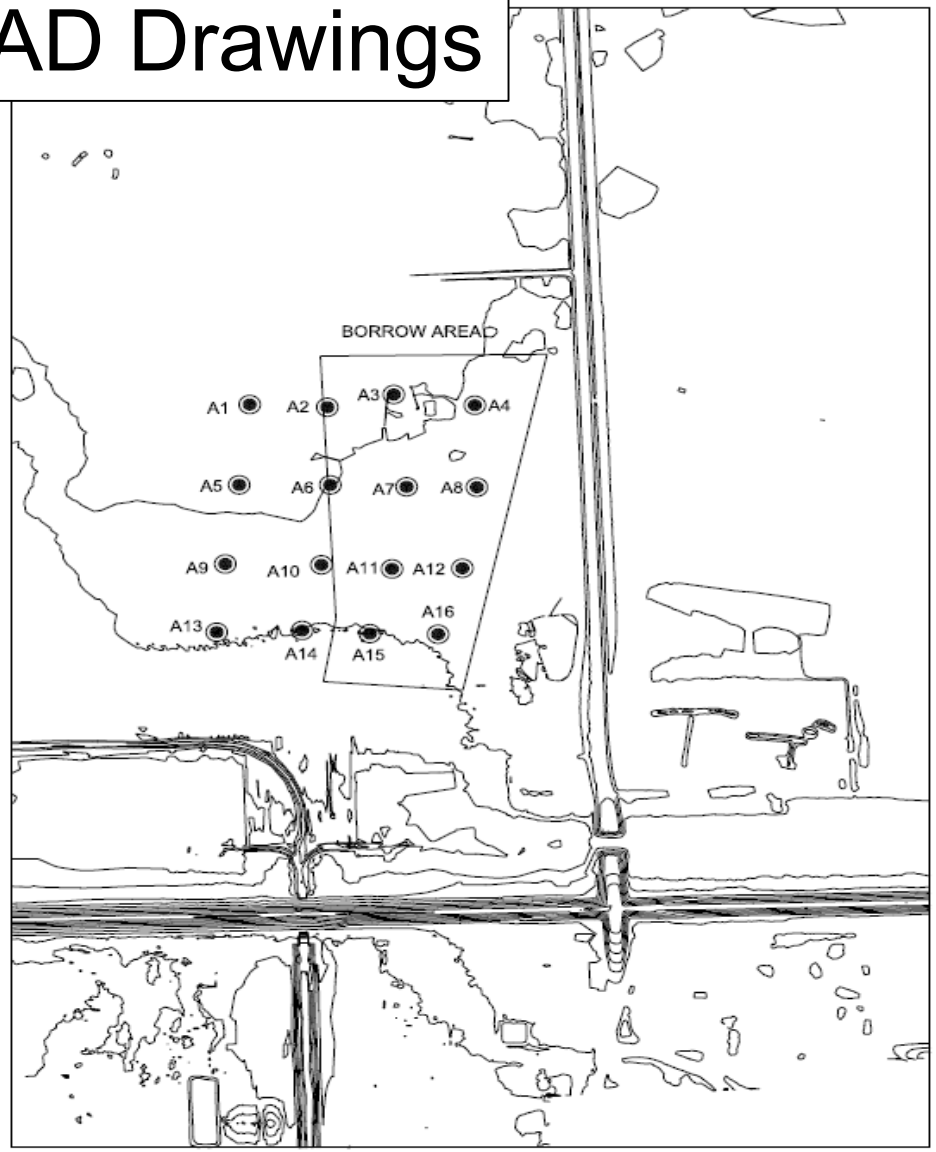
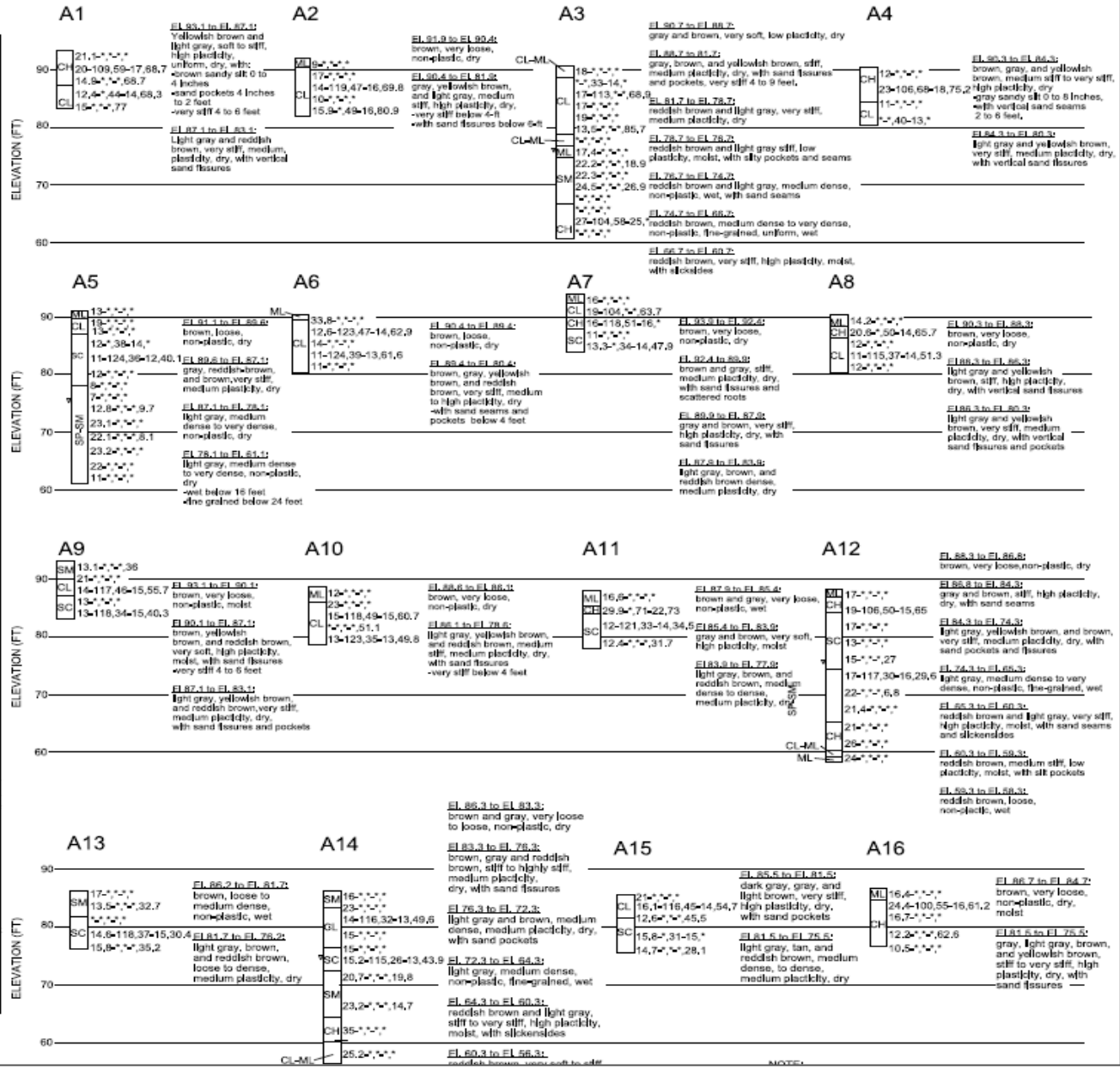
CAD Drawings





Good Data – But can you Compile with other Data easily?

How many borings do you have?

Mosul Dam

Can you find them quickly?

What does it cost to replace them?

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Having Boring Log and Lab Database: Saves $$

Current Projects | Project List | Map

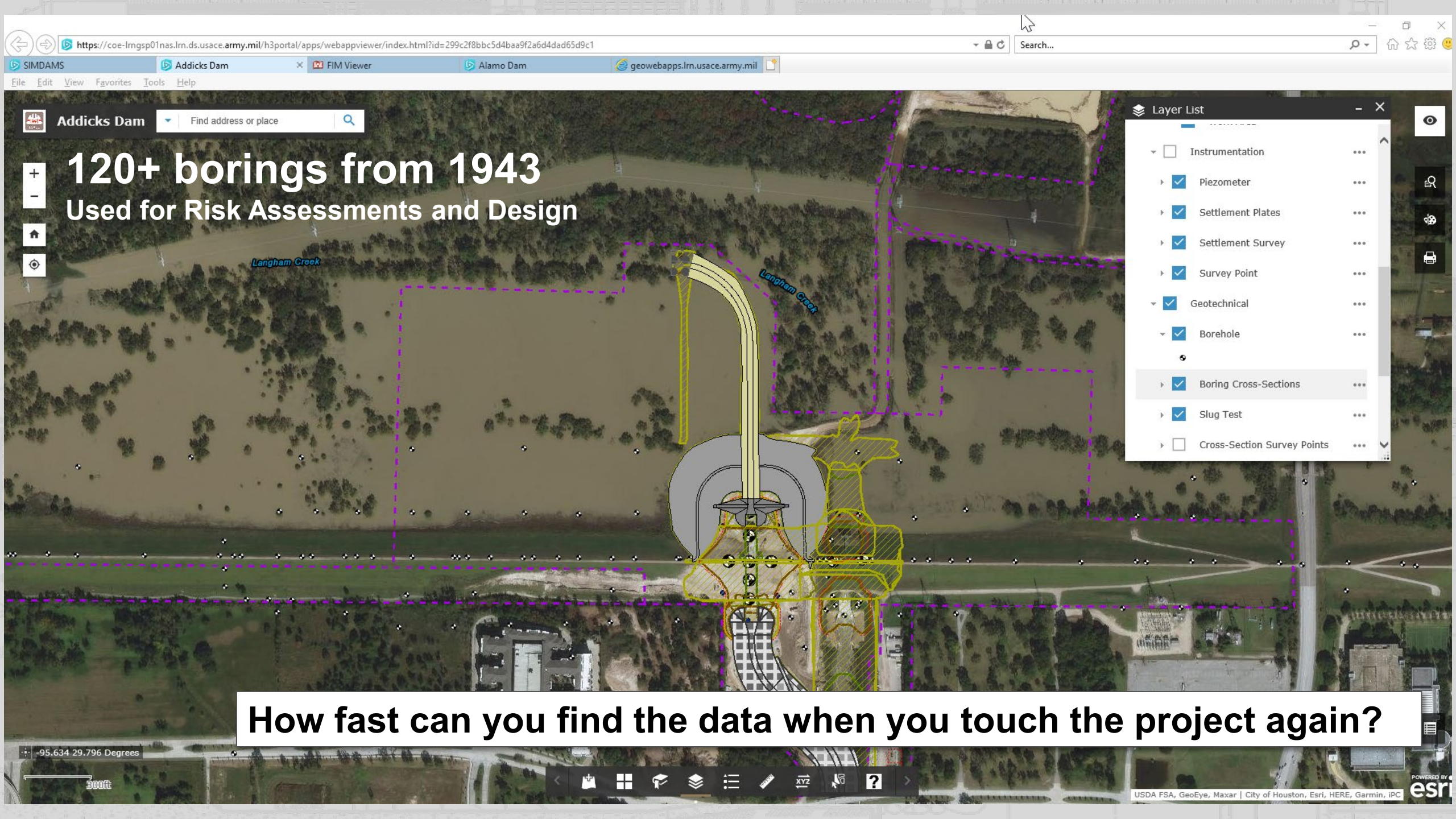
View Project on Map | Toggle Current | Upload Data | Import History | View Documents | View Locations

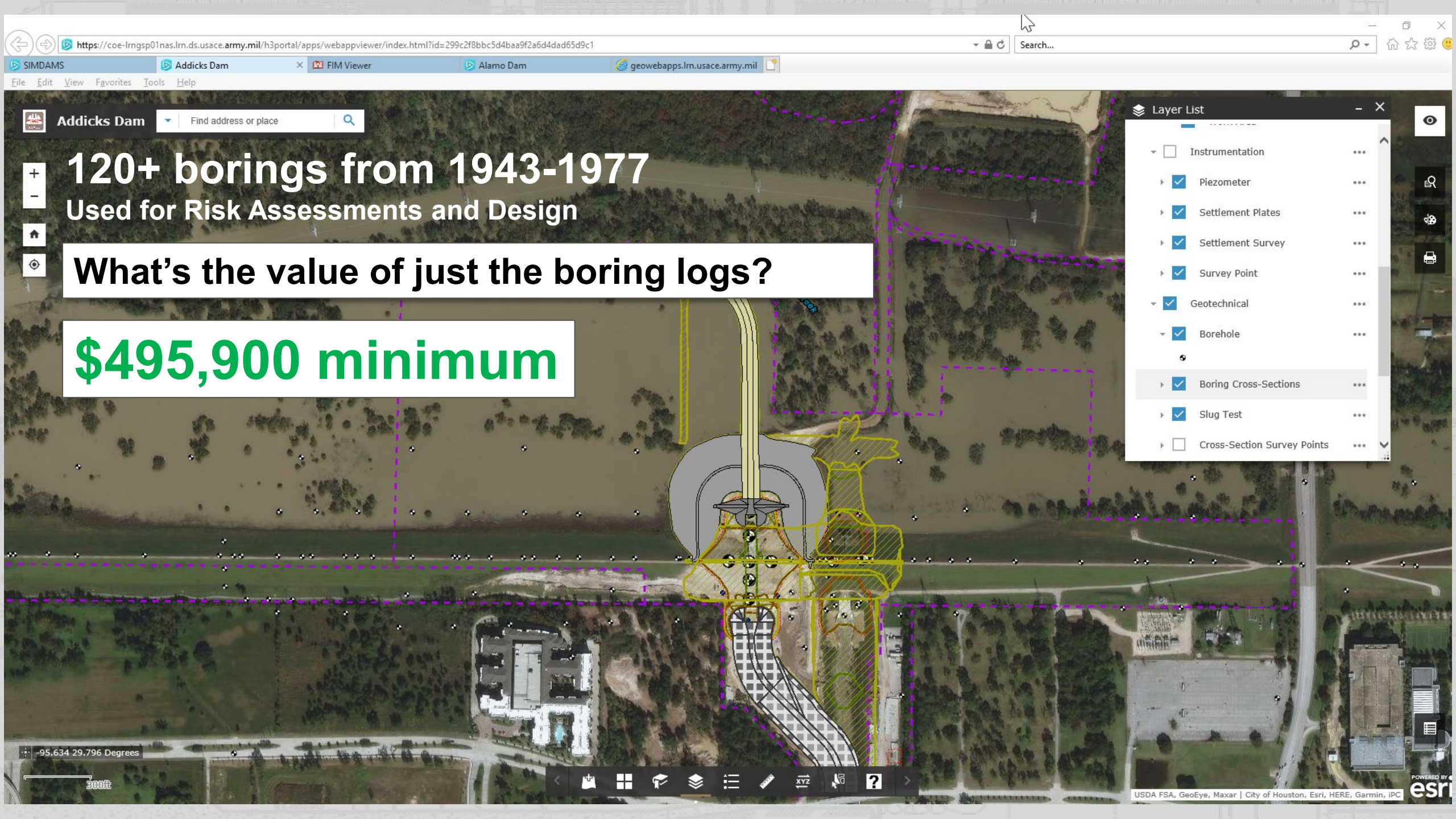
Project ID	Project title	Vertical Datum	Location Type	Status	Category	Location of site	Client name	Contractors name
001-DF- MVK Salinas rio nigua salinas dec 12 2020	RIO NIGUA FLOOD CONT...			Completed	Default			
001-DF- Savannah american creosote works	American Creosote Works	NAVD88	Northing/Easting	Completed	Default			
001-DF- St. Louis 2008 pilot holes	Wood River		Northing/Easting	Completed	Default			
001-DF- St. Paul Fargo	Fargo		Northing/Easting	Completed	Default			
001-Norfolk CSRM Phase 1a	Norfolk CSRM Phase 1a	NAVD88	Northing/Easting	Open	Default	Norfolk, VA	City of Norfolk	
001-SAW-Bogue Banks Test	Bogue Banks Import Test	NAVD88	Northing/Easting	Completed	Default	Carteret County, NC	USACE-SAW	Athena Vibracoring
002-DF- Savannah Alaric	Alaric	NAVD88	Northing/Easting	Completed				
002-DF- St. Louis BP12 Phase 2 (veolia)	BP12 Phase 2 (veolia)		Northing/Easting	Open				
002-DF- St. Paul Moorhead	Fargo-Moorhead Metro Fea...		Northing/Easting	Completed				
003-DF- Savannah ATW	Hunter AAF Dog Kennel	NAVD88		Completed				
003-DF- St. Louis Lower Wood River 2008 ssi	Lower Wood River Underse...		Northing/Easting	Completed				
003-DF- St. Paul Orwell_Dam	orwell		Northing/Easting	Completed	Default			
004-DF- Savannah NorthBelmont	North Belmont PCE Site		Northing/Easting	Completed	Default			
004-DF- St. Louis lower wood river pilot holes FY	Lower Wood River Pilot Hol...	NAVD88	Northing/Easting	Completed	Default			
004-DF- St. Paul Pool_10_McMillan_Island	McMillan Island	NAVD88	Northing/Easting	Completed	Default			
005-DF- Savannah BFGTR_EPA_20160721	BF Goodrich		Northing/Easting	Completed	Default			
005-DF- St. Louis lower wr pilot holes 2019	Lower Wood River Pilot Hol...		Northing/Easting	Completed	Default			
006-DF- Savannah BFGTR_EPA_20160811	BF Goodrich		Northing/Easting	Completed	Default			
006-DF- St. Louis Lower WR Pump Staion 2019	Lower Woodriver Pump Stai...		Northing/Easting	Completed	Default			
007-DF- Savannah BFGTR_EPA_20160812	BF Goodrich		Northing/Easting	Completed	Default			
007-DF- St. Louis Nutwood	Nutwood Seepage analysis ...	NGVD29	Northing/Easting	Completed	Default			
008-DF- Savannah BFGTR_EPA_20160816	B.F. Goodrich Superfund Sit...		Northing/Easting	Completed	Default			
008-DF- St. Louis upper wood river 2008 ssi	Upper Wood River Subsurf...	NAVD88	Northing/Easting	Completed	Default			
009-DF- Savannah BFGTR_EPA_20160817	B.F. Goodrich Superfund Te...		Northing/Easting	Completed	Default			
009-DF- St. Louis UPPER WR pilot holes	UPPER Wood River Pilot H...		Northing/Easting	Completed	Default			

1 2 3 4 5 6

Page 1 of 6 (296 of 296)

4:56 PM
2/6/2021


https://coe-lrngsp01nas.lrn.ds.usace.army.mil/h3portal/apps/webappviewer/index.html?id=299c2f8bbc5d4baa9f2a6d4dad65d9c1
Search...
SIMDAMS
Addicks Dam
FIM Viewer
Alamo Dam
geowebapps.lrn.usace.army.mil
File Edit View Favorites Tools Help
Addicks Dam
Find address or place
120+ borings from 1943
Used for Risk Assessments and Design
Langham Creek
Langham Creek
Layer List
Instrumentation
Piezometer
Settlement Plates
Settlement Survey
Survey Point
Geotechnical
Borehole
Boring Cross-Sections
Slug Test
Cross-Section Survey Points
How fast can you find the data when you touch the project again?
-95.634 29.796 Degrees
300ft
USDA FSA, GeoEye, Maxar | City of Houston, Esri, HERE, Garmin, iPC
esri


https://coe-lrngsp01nas.lrn.ds.usace.army.mil/h3portal/apps/webappviewer/index.html?id=299c2f8bbc5d4baa9f2a6d4dad65d9c1
Search...
SIMDAMS
Addicks Dam
FIM Viewer
Alamo Dam
geowebapps.lrn.usace.army.mil
File Edit View Favorites Tools Help
Addicks Dam
Find address or place
120+ borings from 1943-1977
Used for Risk Assessments and Design
What's the value of just the boring logs?
$495,900 minimum
Layer List
Instrumentation
Piezometer
Settlement Plates
Settlement Survey
Survey Point
Geotechnical
Borehole
Boring Cross-Sections
Slug Test
Cross-Section Survey Points
-95.634 29.796 Degrees
300ft
USDA FSA, GeoEye, Maxar | City of Houston, Esri, HERE, Garmin, iPC
esri

But a database by itself is NOT ENOUGH

You need a data management system!

You have to think through how data flows from generation to use on your project

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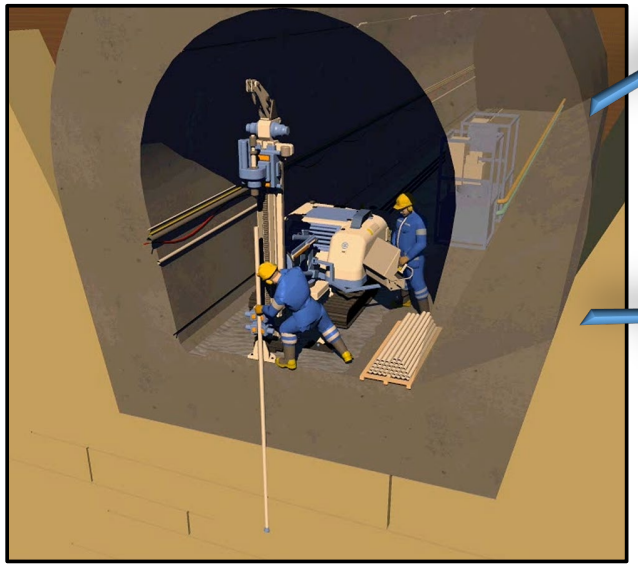
Construction Data Generation

Organization is actually the hard part…



t-grout database
(Trevi)

QA database
(AECOM)

Internet

SIMDAMS

Server

Geodatabase

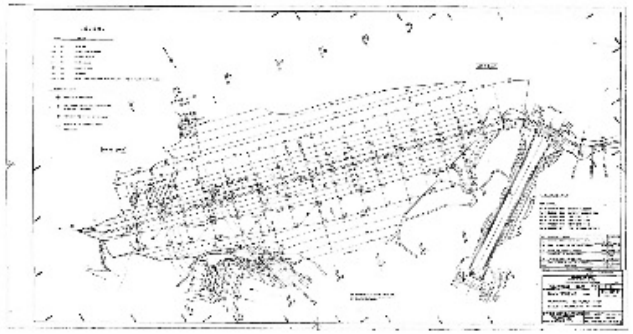
Documents

- Drilling & Grouting
- WPT, Flow Rates, Artesian Pressures
- QA Observations & Notes

SIMDAMS

- Geoprocessing
- Visualization
- Custom Tools

Historical Documents



- As builts
- Historical Grouting Information
- Instrumentation Data
- Boring Logs and Installation Diagrams

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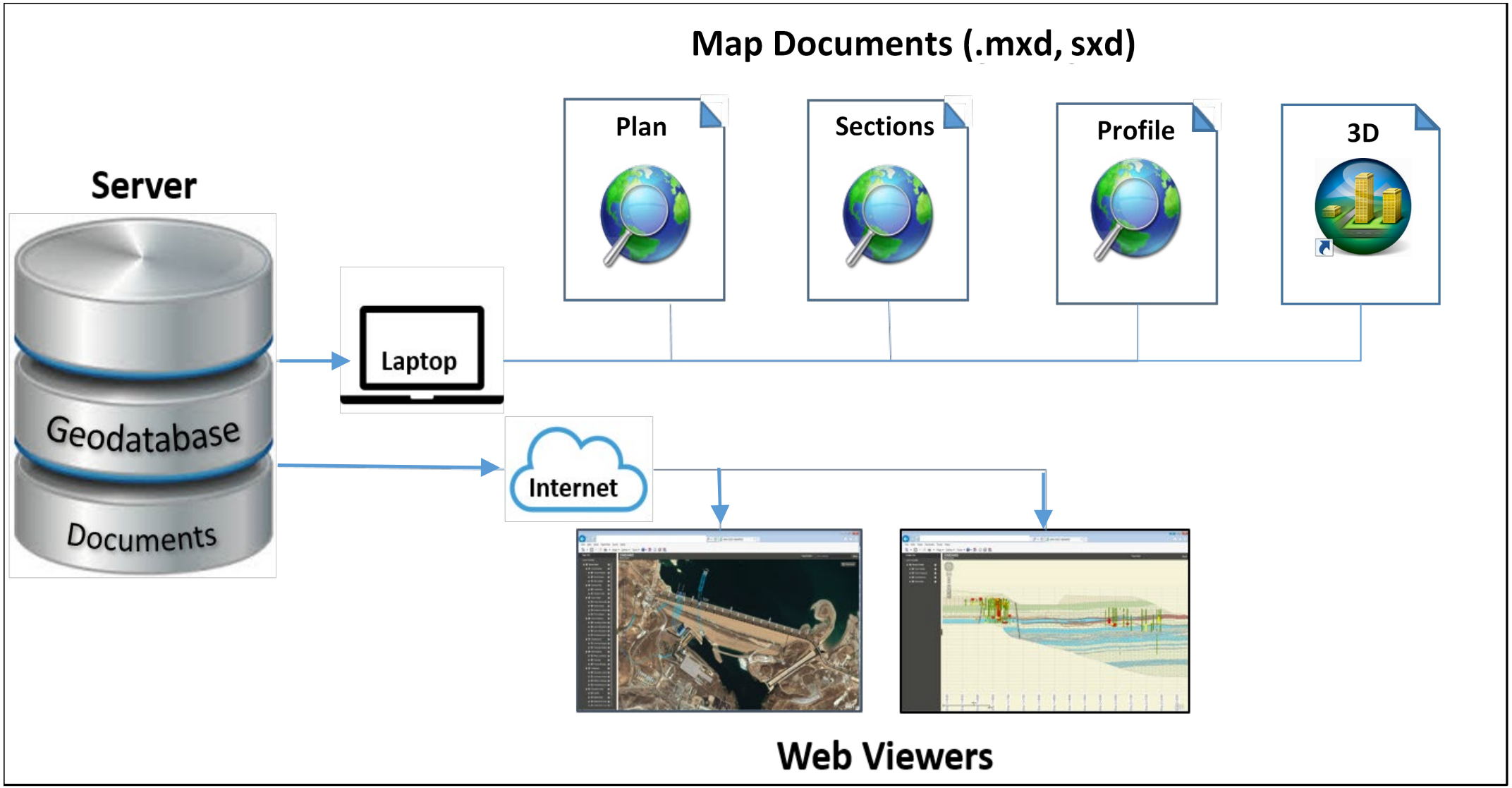

Using the system on the web, in ArcGIS or in ArcScene

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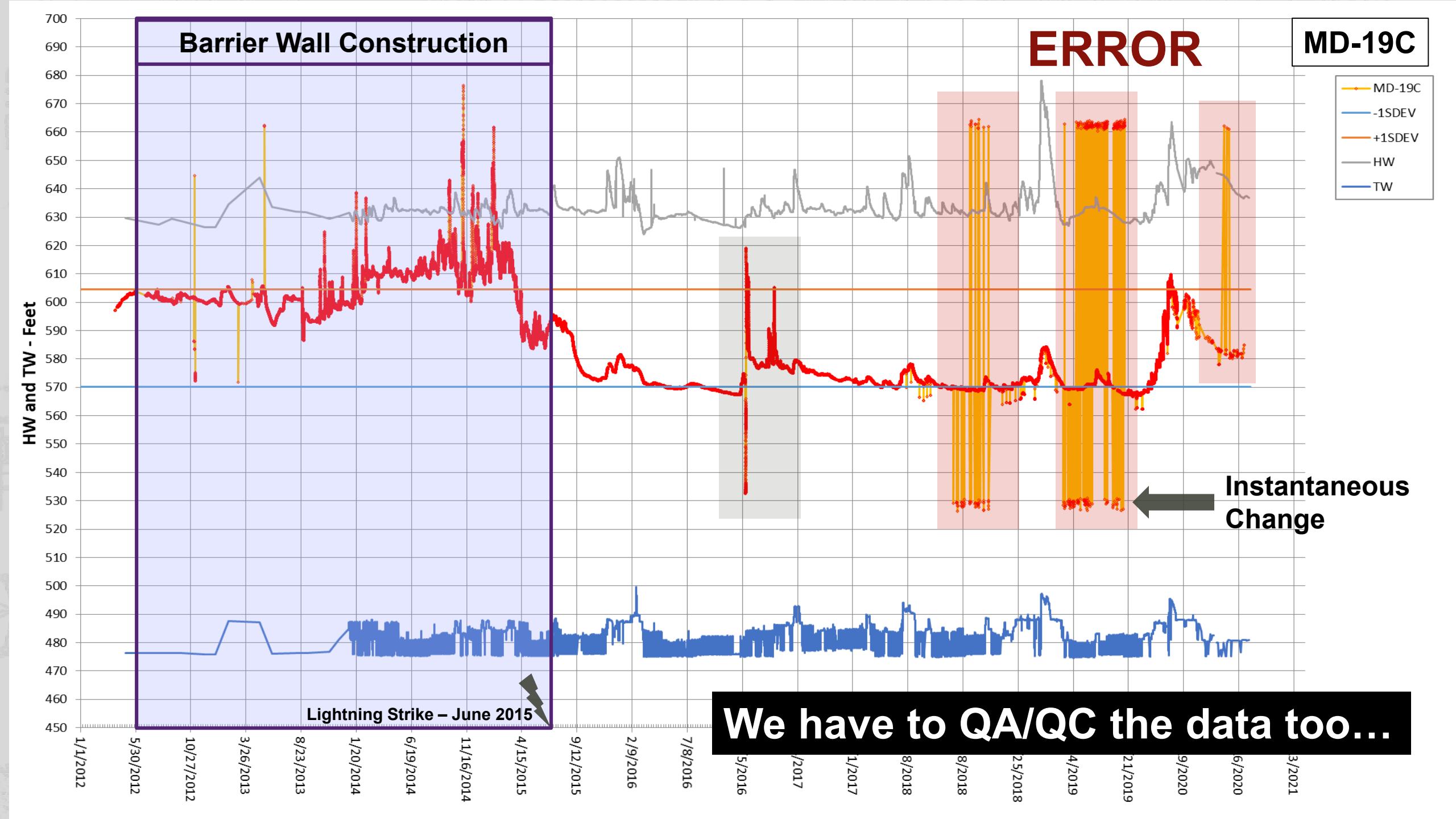
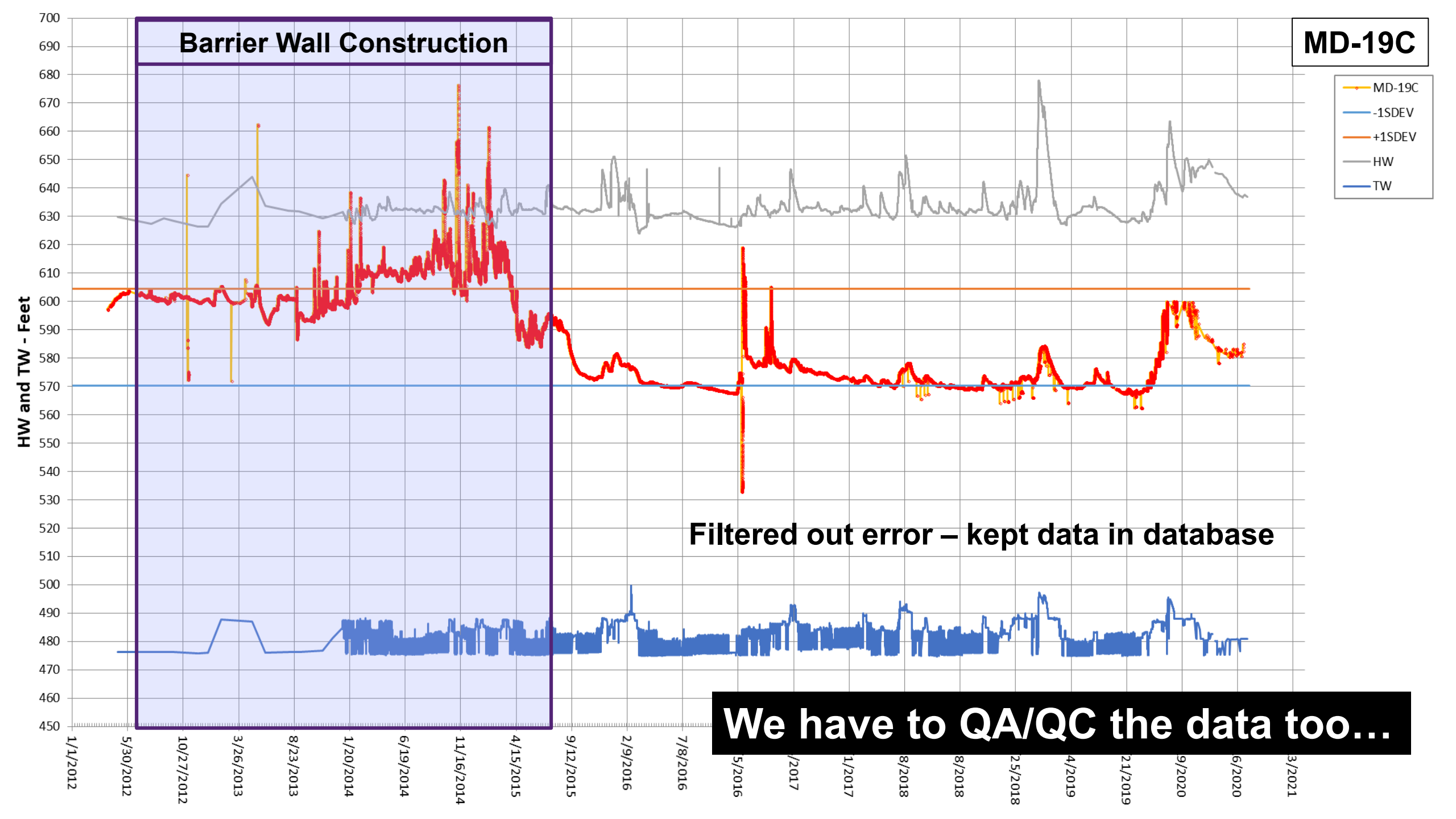
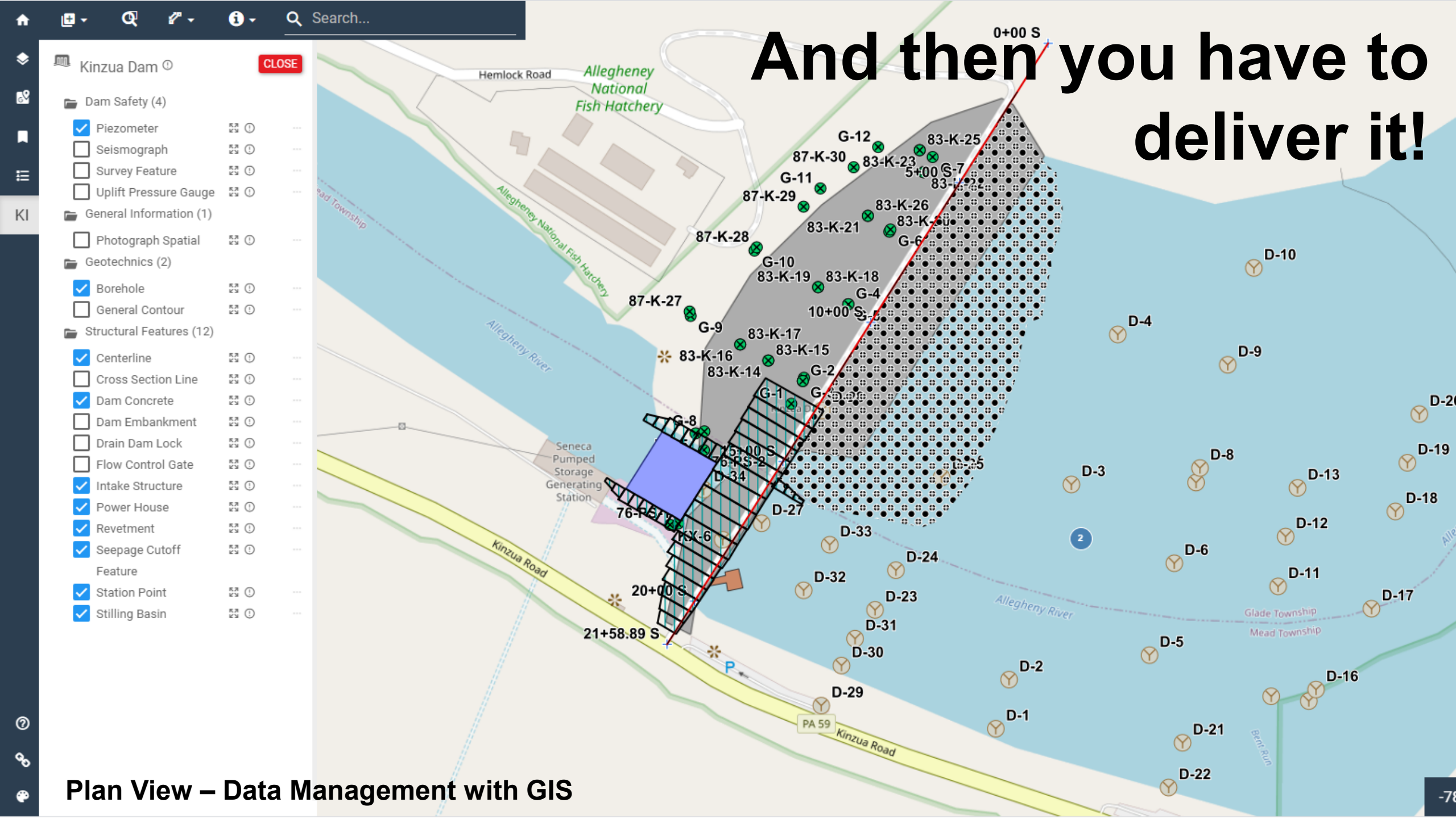
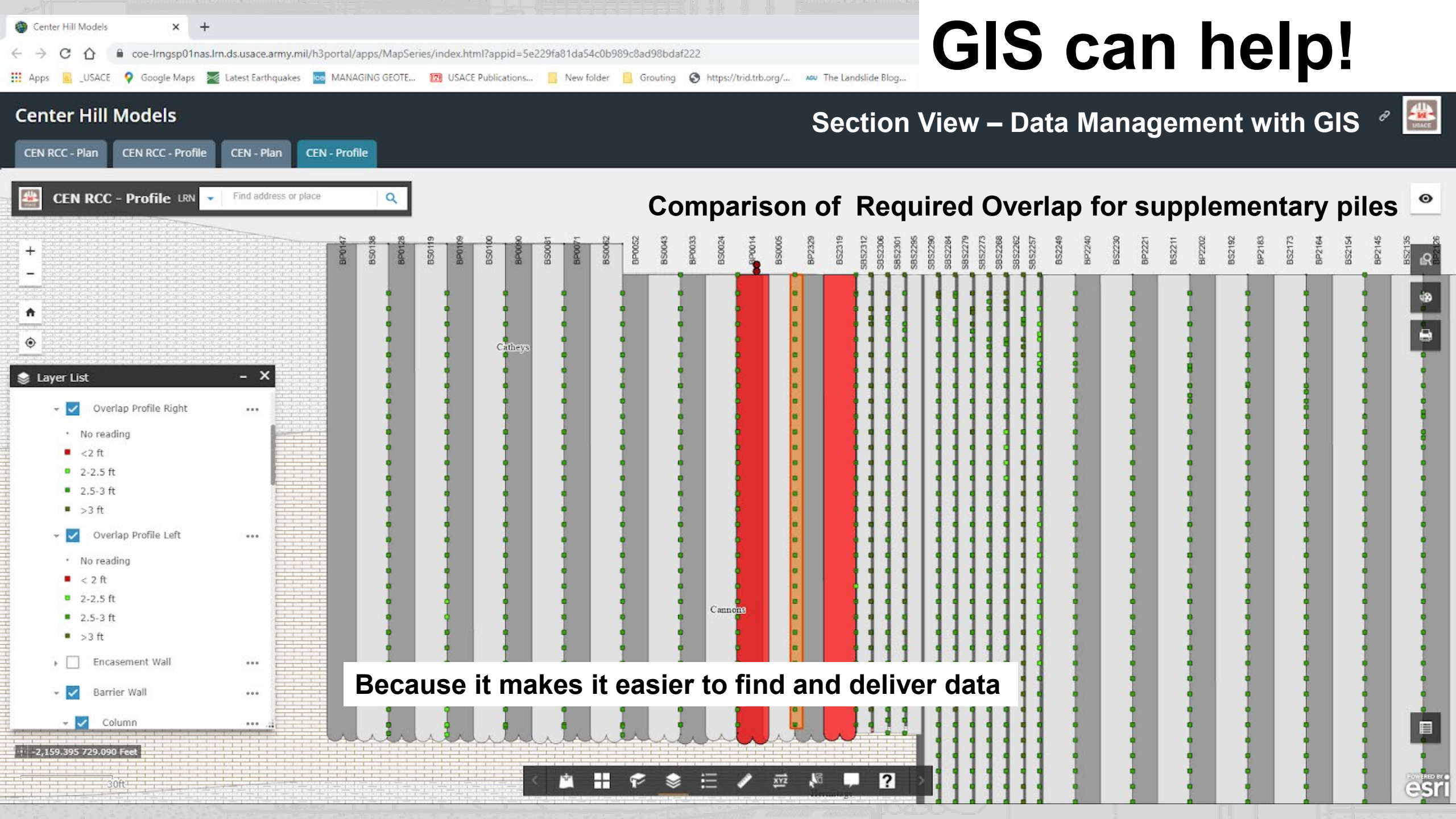

Barrier Wall Construction
ERROR
MD-19C
MD-19C
-1SDEV
+1SDEV
HW
TW
HW and TW - Feet
700
690
680
670
660
650
640
630
620
610
600
590
580
570
560
550
540
530
520
510
500
490
480
470
460
450
1/1/2012
5/30/2012
10/27/2012
3/26/2013
8/23/2013
1/20/2014
6/19/2014
11/16/2014
4/15/2015
9/12/2015
2/9/2016
7/8/2016
Instantaneous Change
Lightning Strike – June 2015
We have to QA/QC the data too…


Barrier Wall Construction
MD-19C
MD-19C
-1SDEV
+1SDEV
HW
TW
HW and TW - Feet
700
690
680
670
660
650
640
630
620
610
600
590
580
570
560
550
540
530
520
510
500
490
480
470
460
450
1/1/2012
5/30/2012
10/27/2012
3/26/2013
8/23/2013
1/20/2014
6/19/2014
11/16/2014
4/15/2015
9/12/2015
2/9/2016
7/8/2016
Filtered out error – kept data in database
We have to QA/QC the data too…


Search...
Kinzua Dam
CLOSE
Dam Safety (4)
Piezometer
Seismograph
Survey Feature
Uplift Pressure Gauge
General Information (1)
Photograph Spatial
Geotechnics (2)
Borehole
General Contour
Structural Features (12)
Centerline
Cross Section Line
Dam Concrete
Dam Embankment
Drain Dam Lock
Flow Control Gate
Intake Structure
Power House
Revetment
Seepage Cutoff Feature
Station Point
Stilling Basin
And then you have to deliver it!
Plan View – Data Management with GIS
Hemlock Road
Allegheny National Fish Hatchery
Allegheny River
Seneca Pumped Storage Generating Station
Kinzua Road
PA 59
Glade Township
Mead Township
0+00 S
5+00 S
10+00 S
20+00 S
21+58.89 S
G-12
87-K-30
83-K-25
83-K-23
G-11
87-K-29
83-K-26
83-K-21
87-K-28
G-10
83-K-19
83-K-18
87-K-27
G-9
83-K-17
83-K-16
83-K-15
83-K-14
G-2
G-1
G-8
D-34
D-27
D-33
D-24
D-32
D-23
D-31
D-30
D-29
D-2
D-1
D-5
D-16
D-21
D-22
D-10
D-4
D-9
D-3
D-8
D-13
D-19
D-18
D-12
D-6
D-11
D-17

GIS can help!


Center Hill Models
coe-lrngsp01nas.lrn.ds.usace.army.mil/h3portal/apps/MapSeries/index.html?appid=5e229fa81da54c0b989c8ad98bdaf222
Center Hill Models
Section View – Data Management with GIS
CEN RCC - Plan
CEN RCC - Profile
CEN - Plan
CEN - Profile
CEN RCC - Profile LRN
Find address or place
Comparison of Required Overlap for supplementary piles
Layer List
Overlap Profile Right
No reading
<2 ft
2-2.5 ft
2.5-3 ft
>3 ft
Overlap Profile Left
No reading
< 2 ft
2-2.5 ft
2.5-3 ft
>3 ft
Encasement Wall
Barrier Wall
Column
Catheys
Cannons
Because it makes it easier to find and deliver data
-2,159.395 729.090 Feet
30ft
esri

Wolf Creek Dam

Switchyard

Sinkholes (1968)

Muddy Flow (1967)

Barrier Wall

Power house

Concrete Dam

Core Trench

Core Trench

Top of Rock Contours

<520	560-570
520-530	570-580
530-540	580-590
540-550	590-600
550-560	600-800

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Karst Features

Vertical Solutioning along Joints
LARGE Cave Formation
Core trench was located **IN** a solution feature

Switchyard

Sinkholes (1968)

Muddy Flow (1967)

Barrier Wall

Power house

Concrete Dam

Core Trench

Core Trench

Top of Rock Contours

<520	560-570
520-530	570-580
530-540	580-590
540-550	590-600
550-560	600-800

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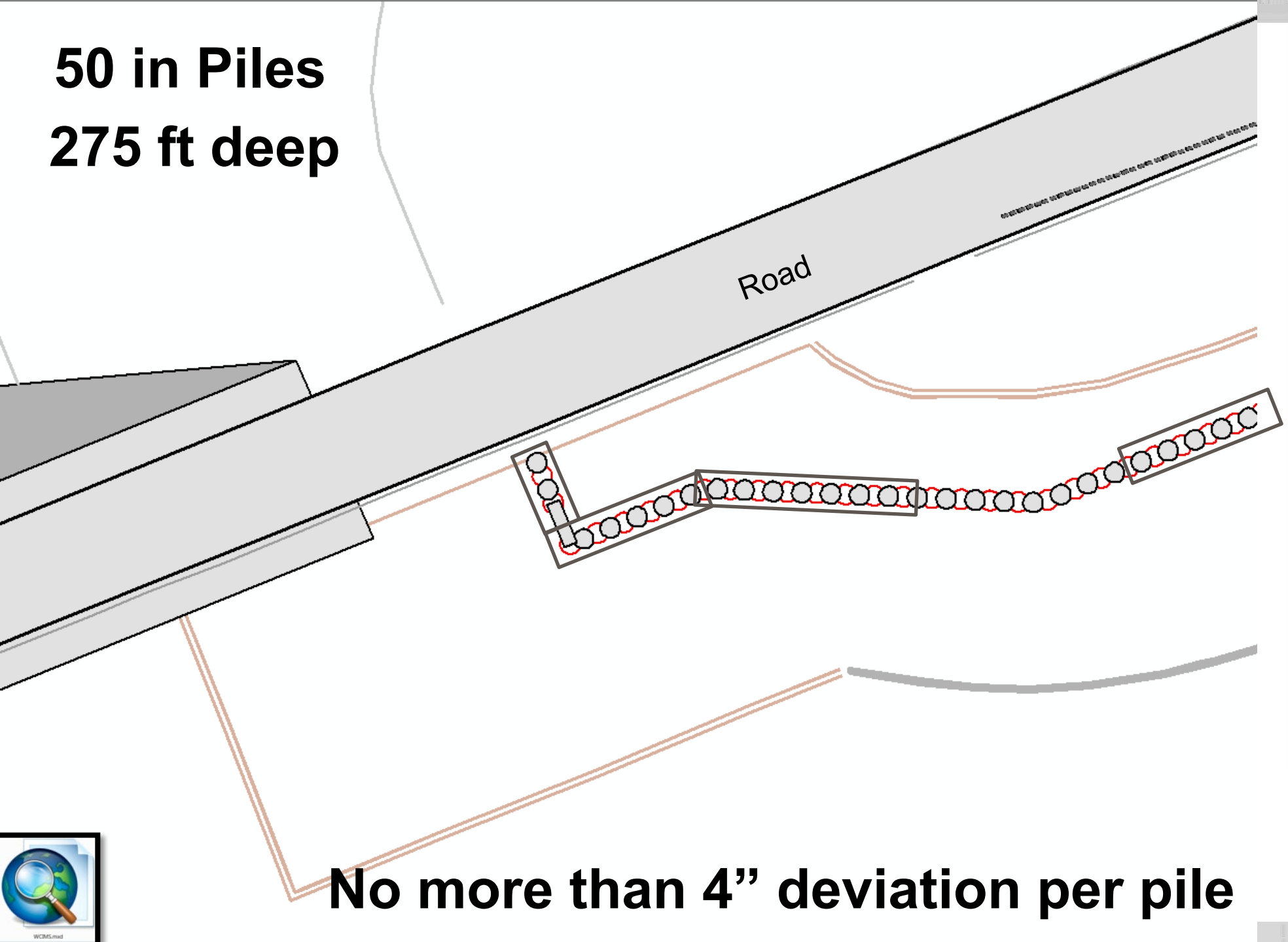
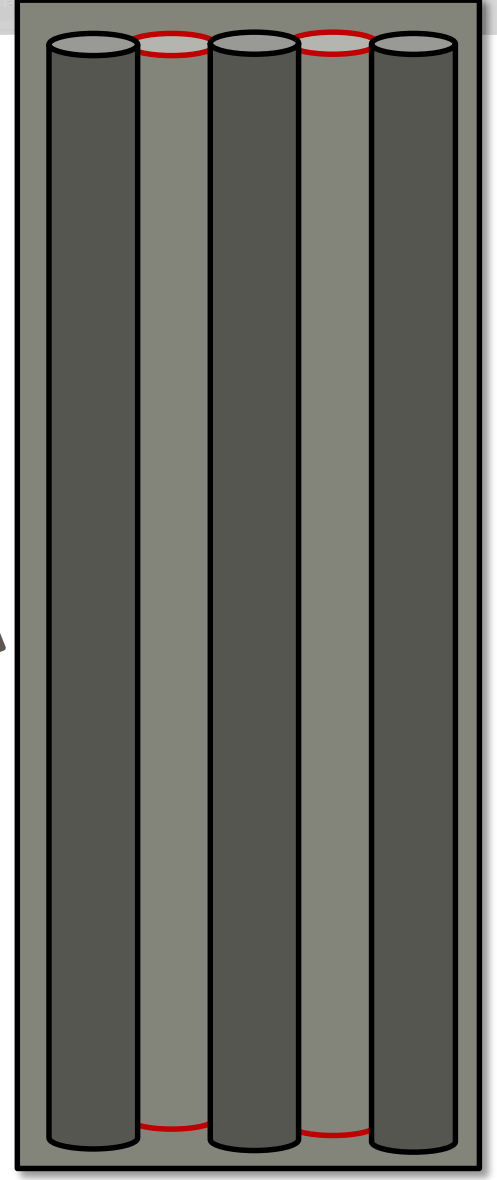
50 in Piles
275 ft deep





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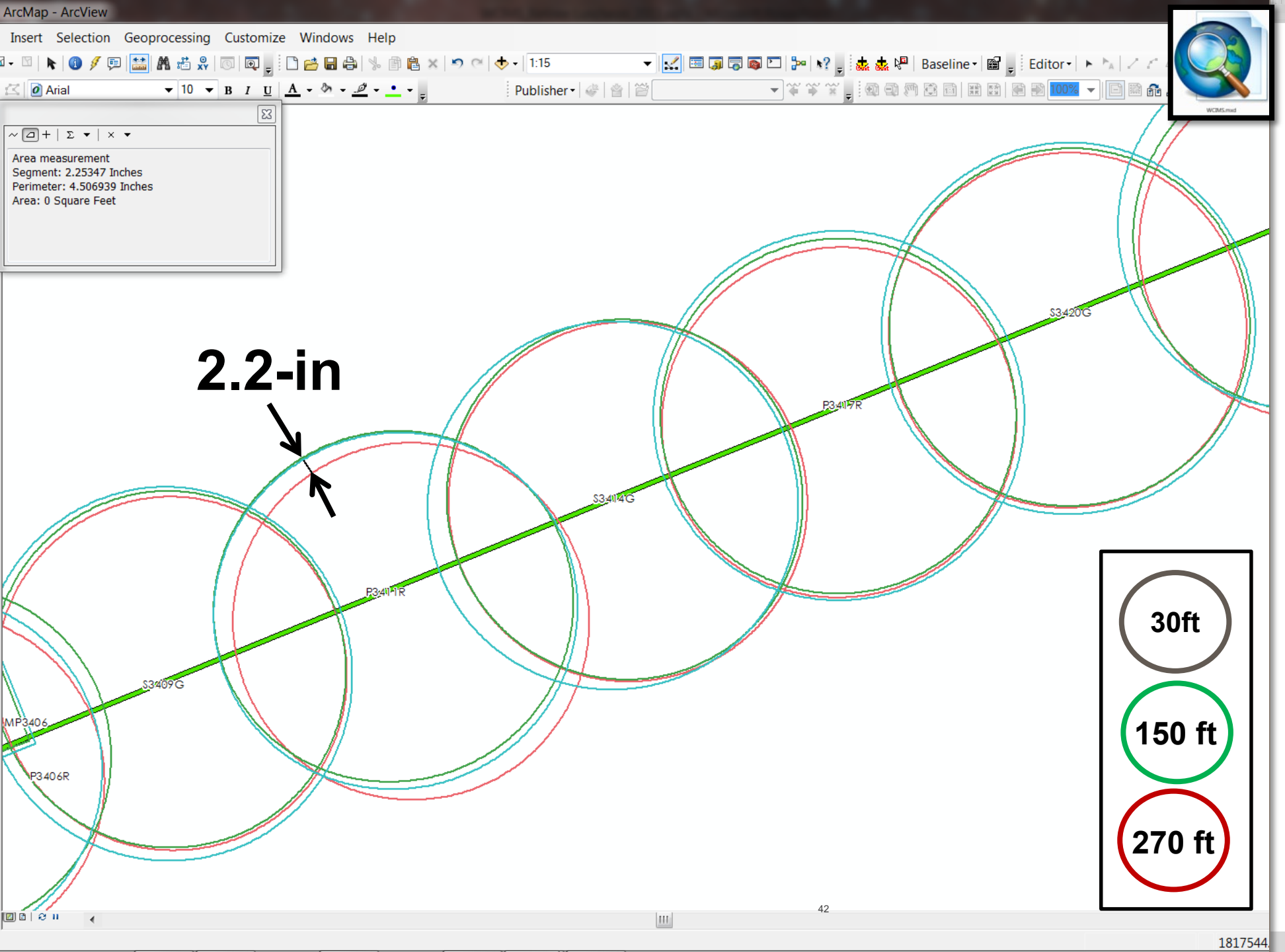
U.S.ARMY

No more than 4” deviation per pile



We had to assess each pile as we went along.

We could accept no more than 4” deviation per pile

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U.S.ARMY

Analyze

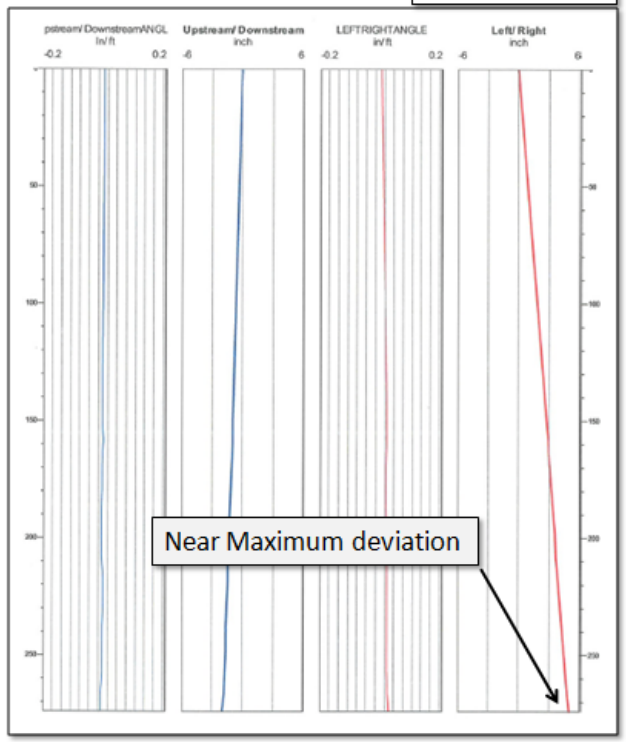
Pile S3845G

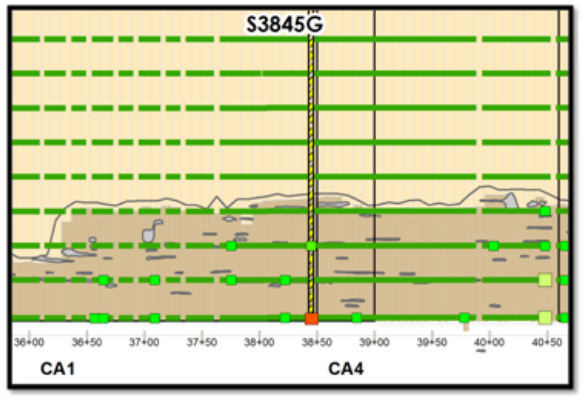
Secondary pile stayed within verticality tolerance, but drifted to almost it's maximum allowable deviation in the up-station direction. Pile P3842R also deviated to the down station direction resulting in a wall thickness just slightly below 2-feet. This pile is 0.6 inches short of the specification.

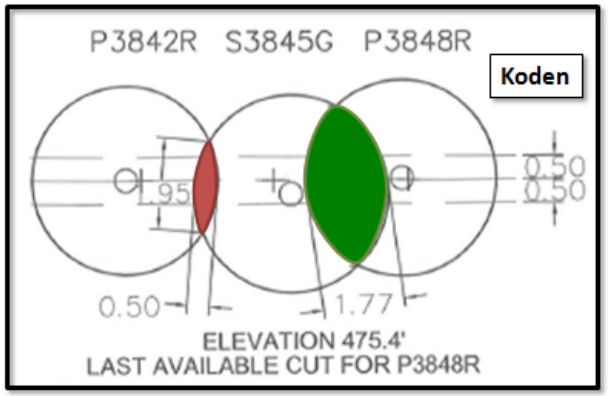
A secondary analysis was performed looking at the area geology. As the deviation was only at the base of the wall and did not line up with flaws in the foundation, the pile was accepted.

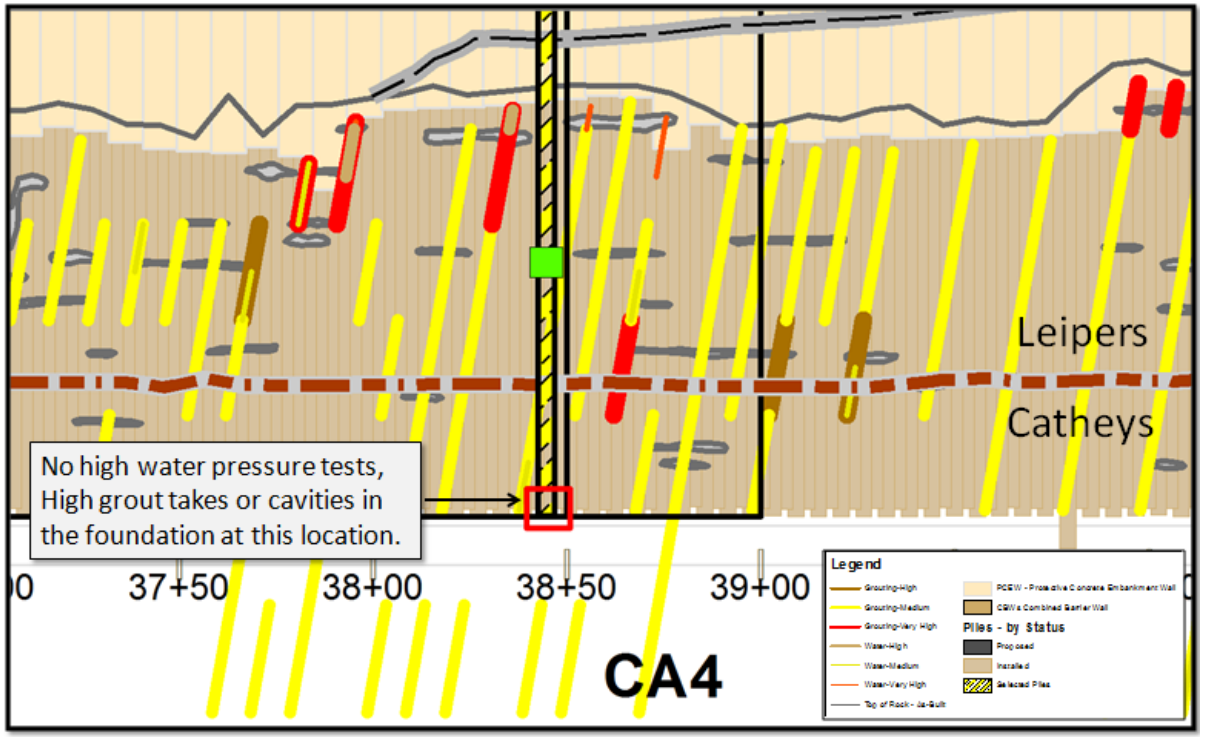
To date, this is the only measurement of wall thickness less than the specified 2-ft (24-in).

Wirth Inclinometer









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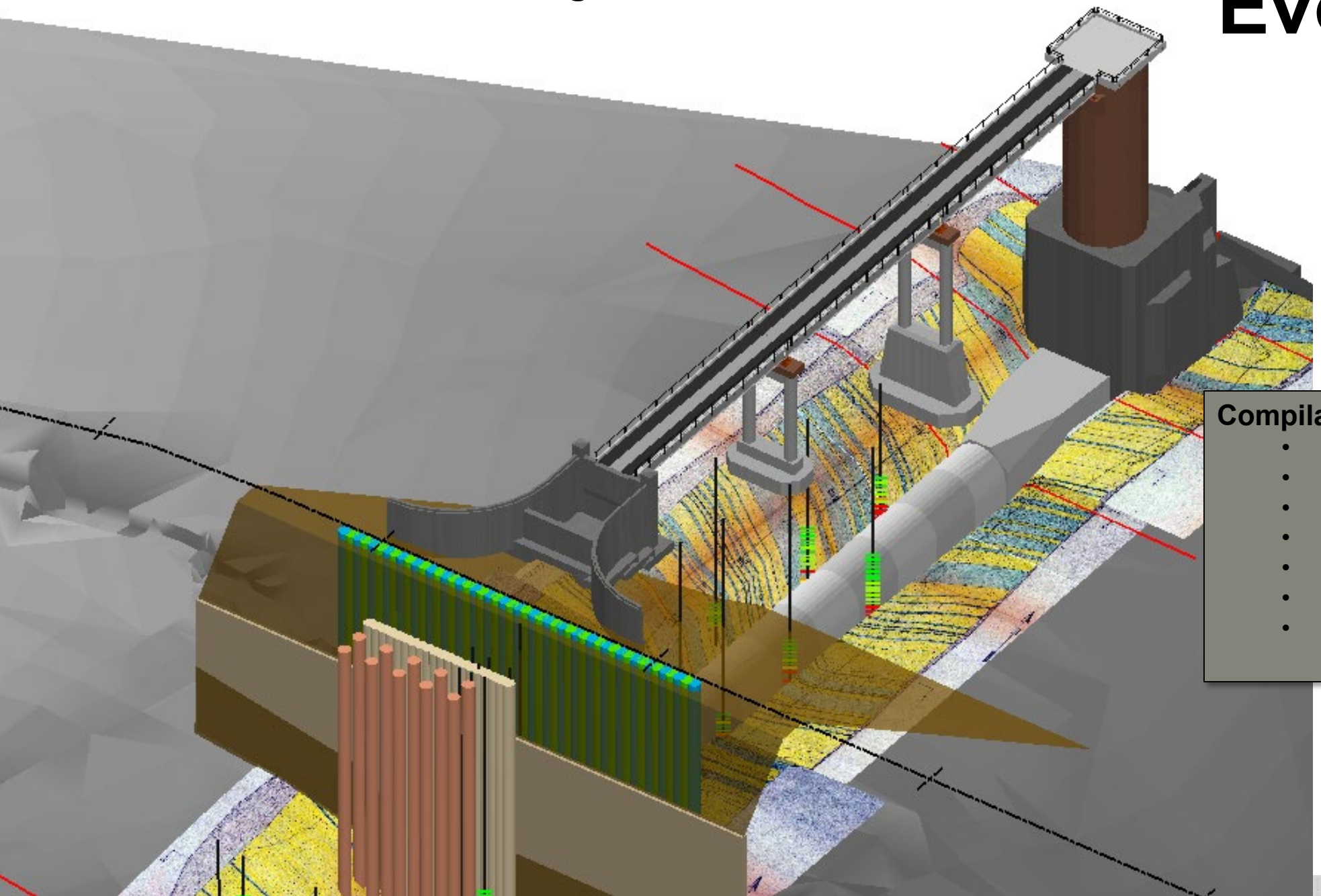
Pine Creek Dam – 3D GIS During Construction

Evolutionary



Compilation of all the data in 3D

- Bedrock DTM
- Geology Foundation Map
- SPT testing
- Intake Tower & Pipe
- Clay Core
- New Barrier Wall
- New Sand Filter

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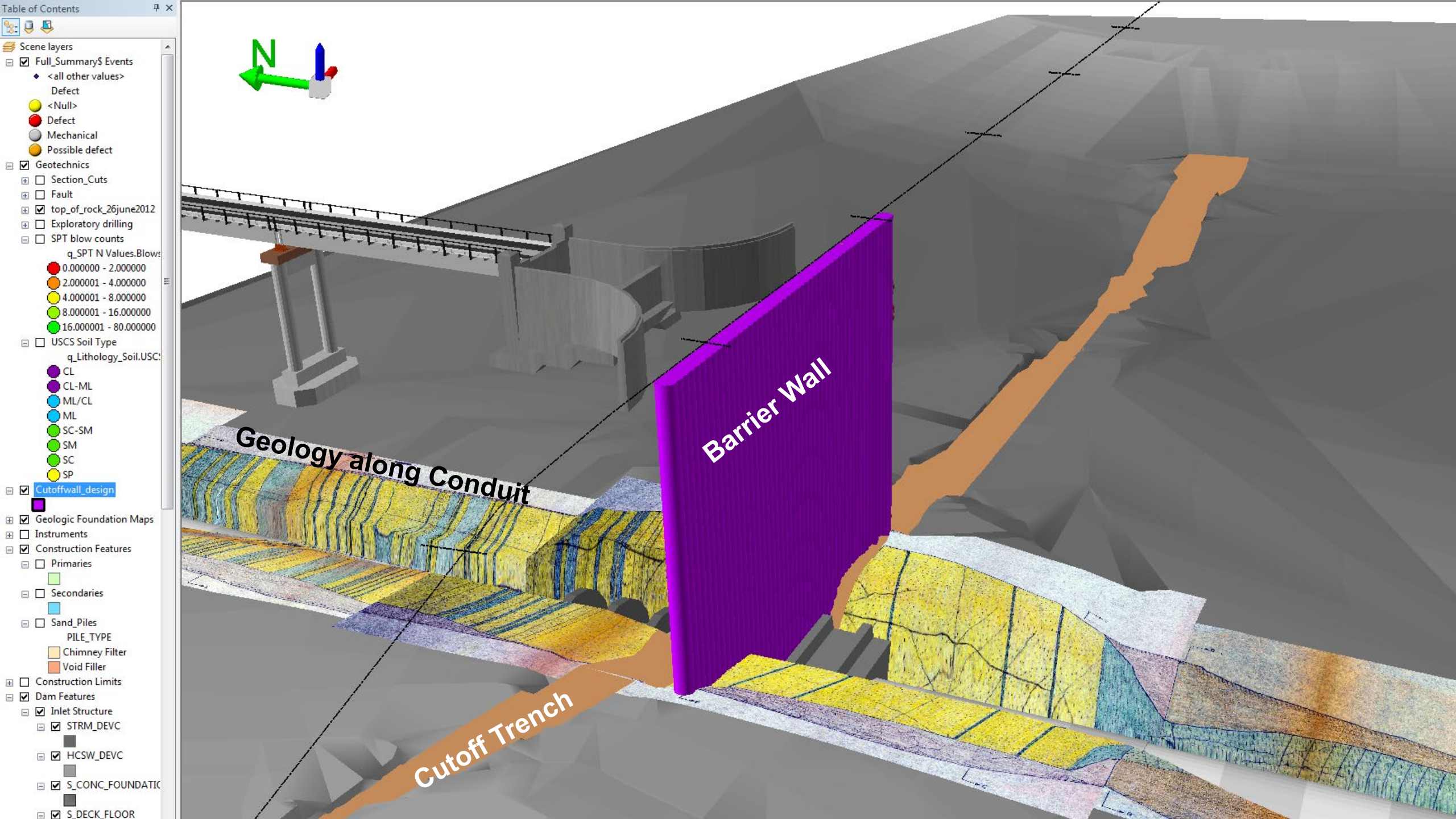
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Scene layers
Full_Summary$ Events
<all other values>
Defect
<Null>
Defect
Mechanical
Possible defect
Geotechnics
Section_Cuts
Fault
top_of_rock_26june2012
Exploratory drilling
SPT blow counts
q_SPT N Values.Blows
0.000000 - 2.000000
2.000001 - 4.000000
4.000001 - 8.000000
8.000001 - 16.000000
16.000001 - 80.000000
USCS Soil Type
q_Lithology_Soil.USC
CL
CL-ML
ML/CL
ML
SC-SM
SM
SC
SP
Cutoffwall_design
Geologic Foundation Maps
Instruments
Construction Features
Primaries
Secondaries
Sand_Piles
PILE_TYPE
Chimney Filter
Void Filler
Construction Limits
Dam Features
Inlet Structure
STRM_DEVC
HCSW_DEVC
S_CONC_FOUNDATIC
S_DECK_FLOOR
N
Geology along Conduit
Barrier Wall
Cutoff Trench

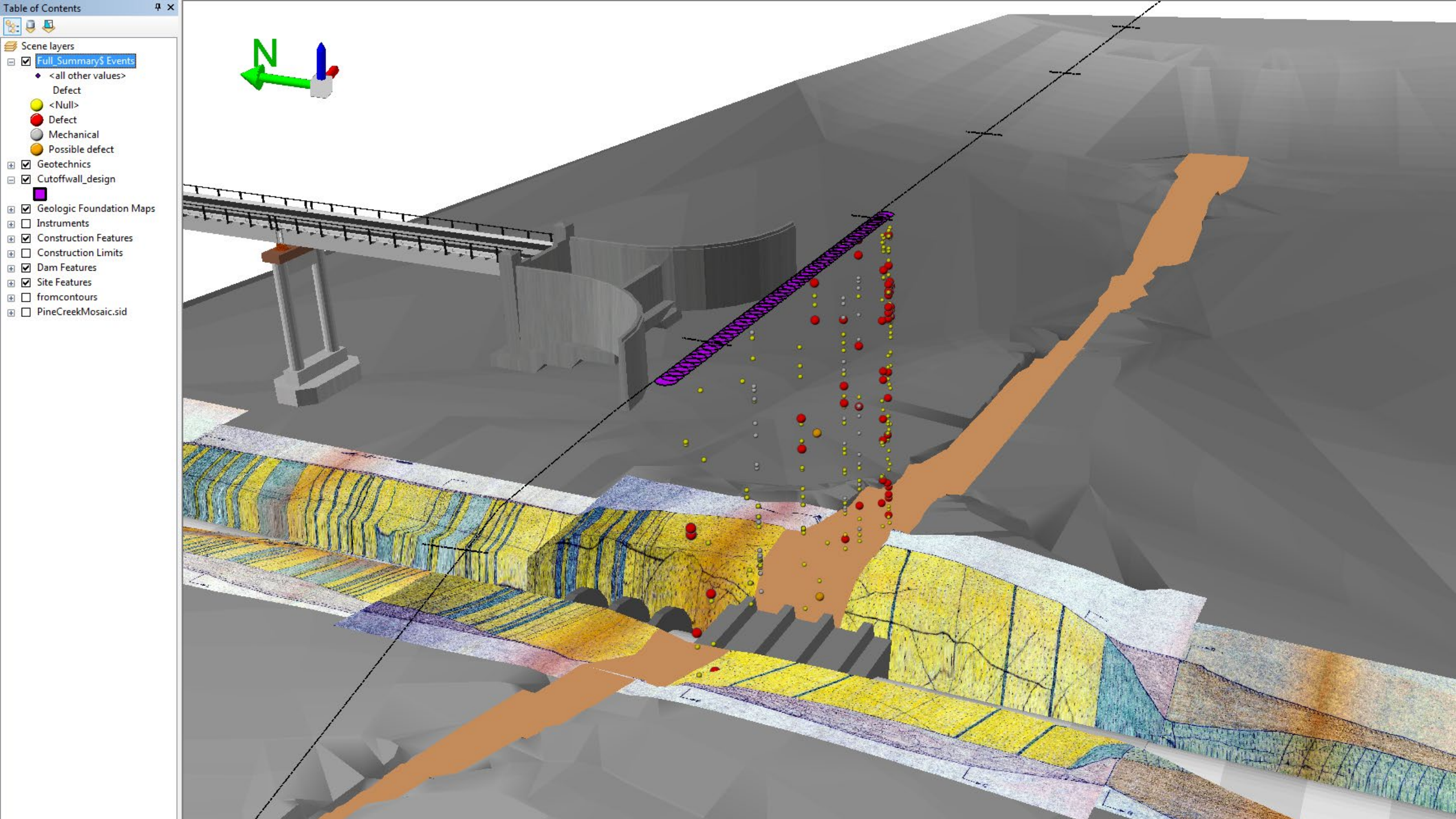


Table of Contents
Scene layers
Full_Summary$ Events
<all other values>
Defect
<Null>
Defect
Mechanical
Possible defect
Geotechnics
Cutoffwall_design
Geologic Foundation Maps
Instruments
Construction Features
Construction Limits
Dam Features
Site Features
fromcontours
PineCreekMosaic.sid
N

Websites make it EASY to deliver data to everyone on the project

Center Hill Models

coe-lrngsp01nas.lrn.ds.usace.army.mil/h3

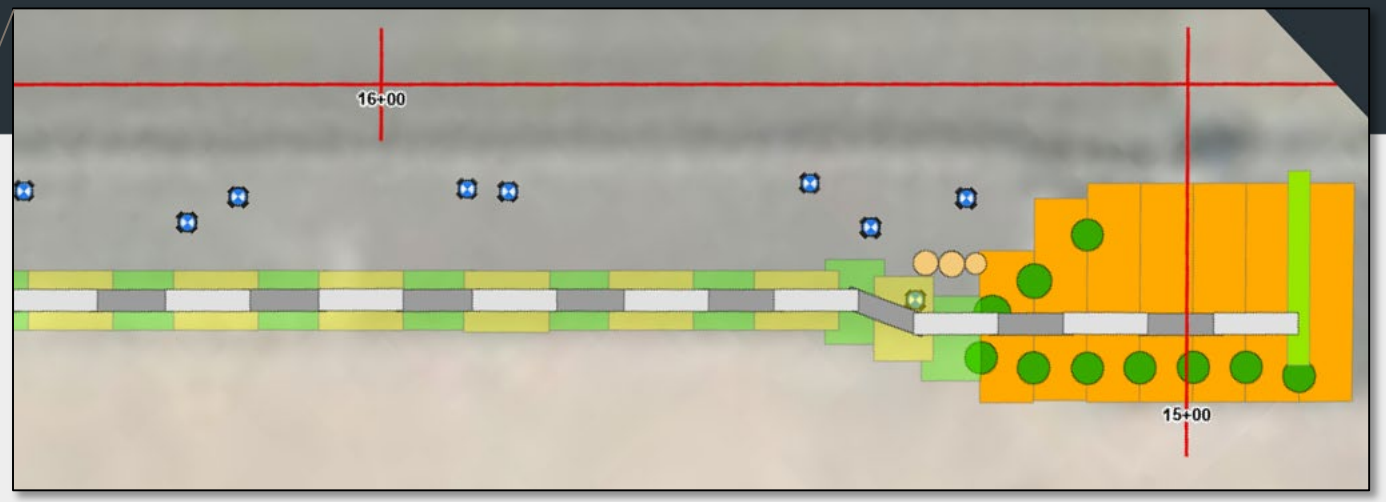
Apps _USACE Latest Earthquakes MANAGING GEOTE... USACE Publications... New folder Grouting https://trid.trb.org/... The Landslide Blog... NASA Landslide Vie... Slope Stability and...

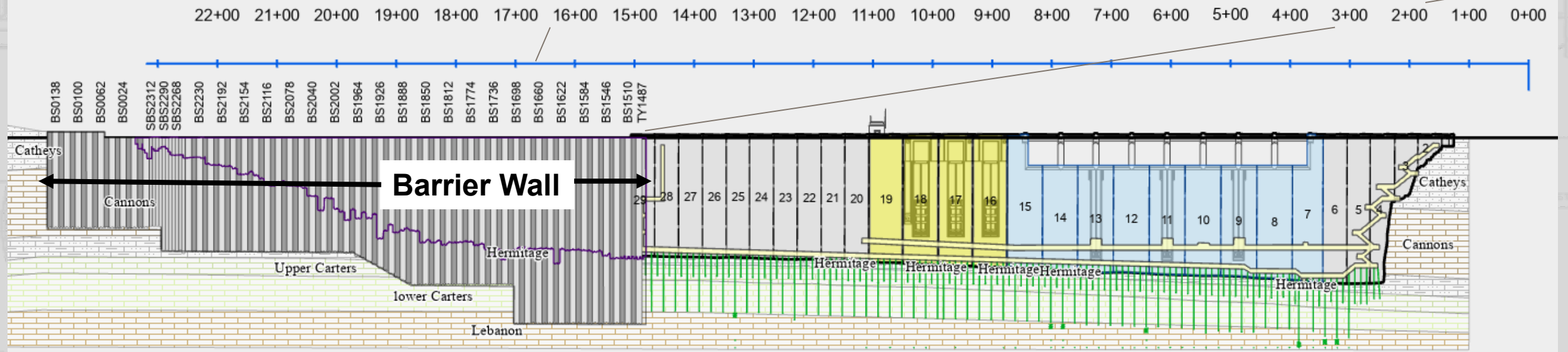
Center Hill Models

CEN RCC - Plan | CEN RCC - Profile | CEN - Plan | CEN - Profile

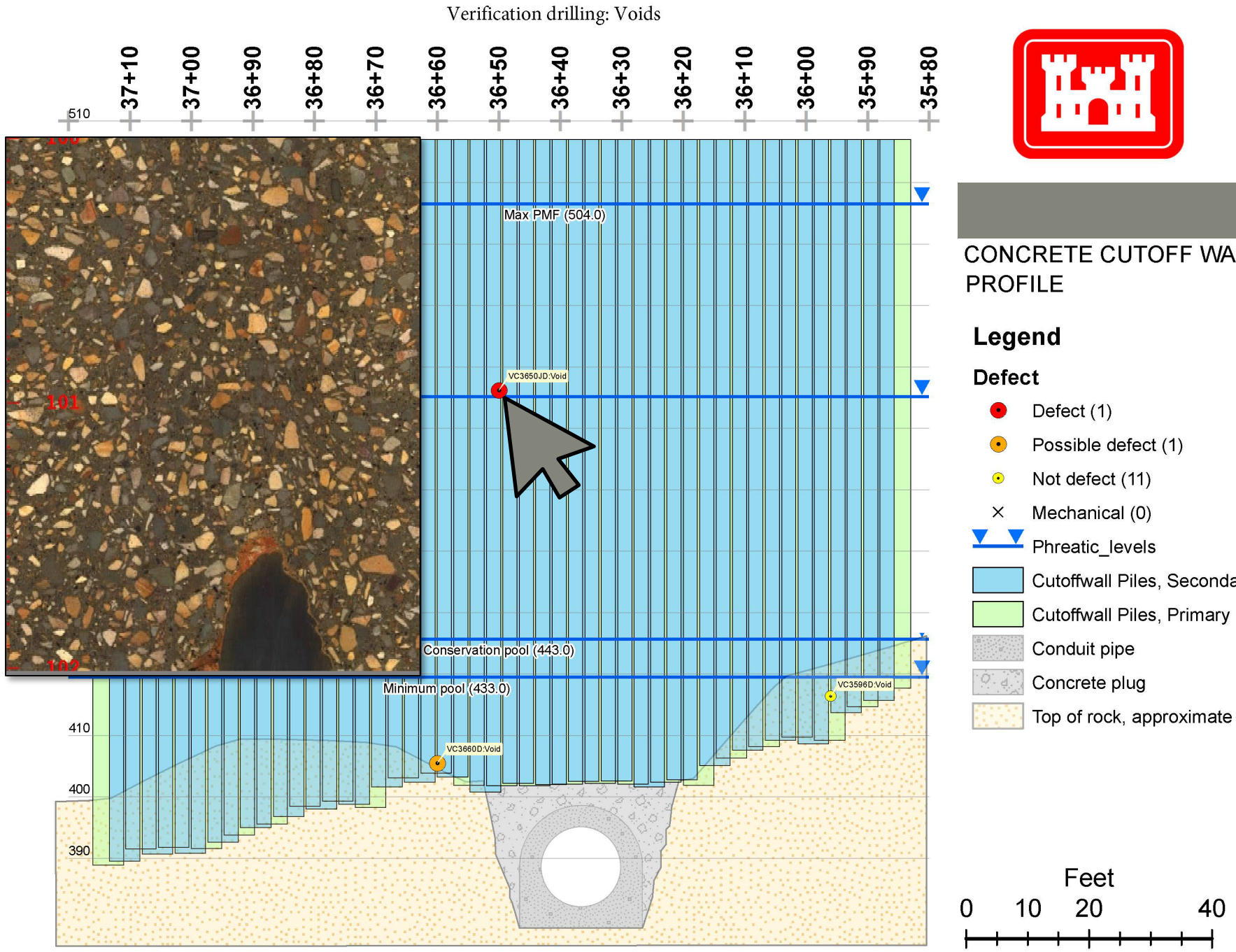
CEN RCC - Profile LRN | Find address or place

Bottom of Encasement Wall





Most of these tools are “out of the box” with off the shelf technology



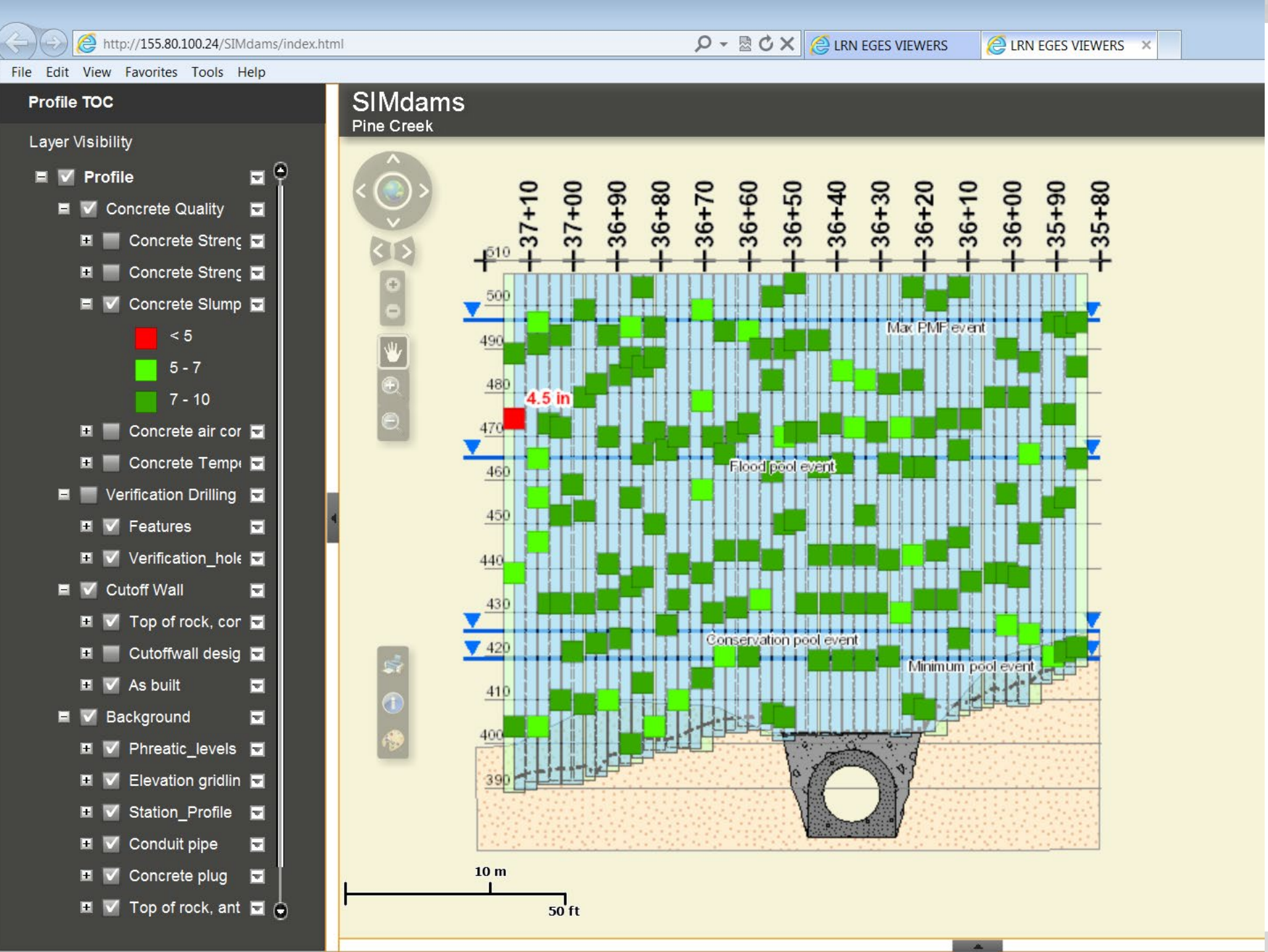
2D Barrier Wall View in GIS

Now we can see and assess any concrete void in the wall.

Pine Creek Dam

US Army Corps of Engineers ®

U.S.ARMY

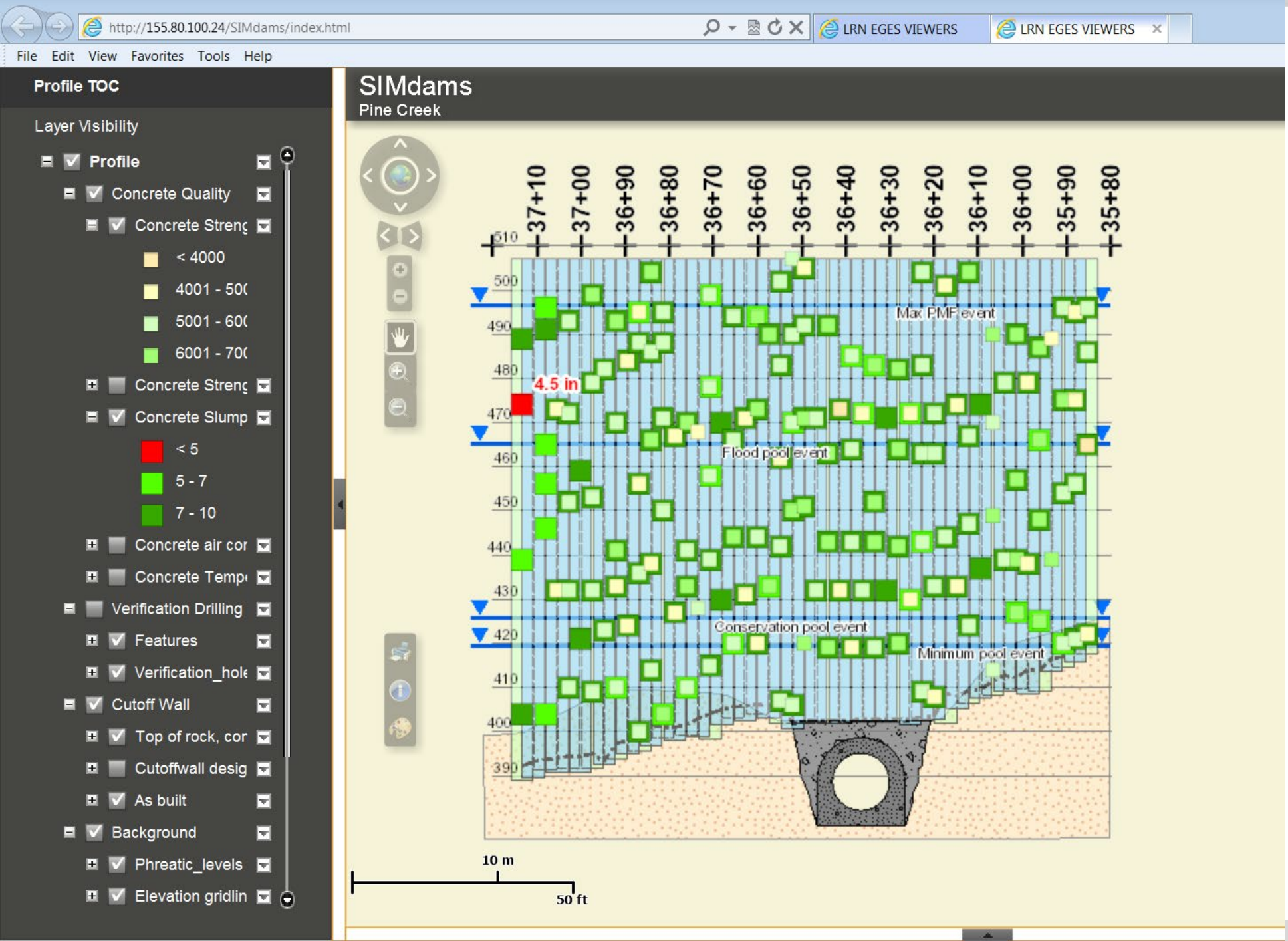


And Compare everything to concrete test results

Slump Results

US Army Corps of Engineers ®

U.S.ARMY



And Compare everything to concrete test results

Slump and Strength Results

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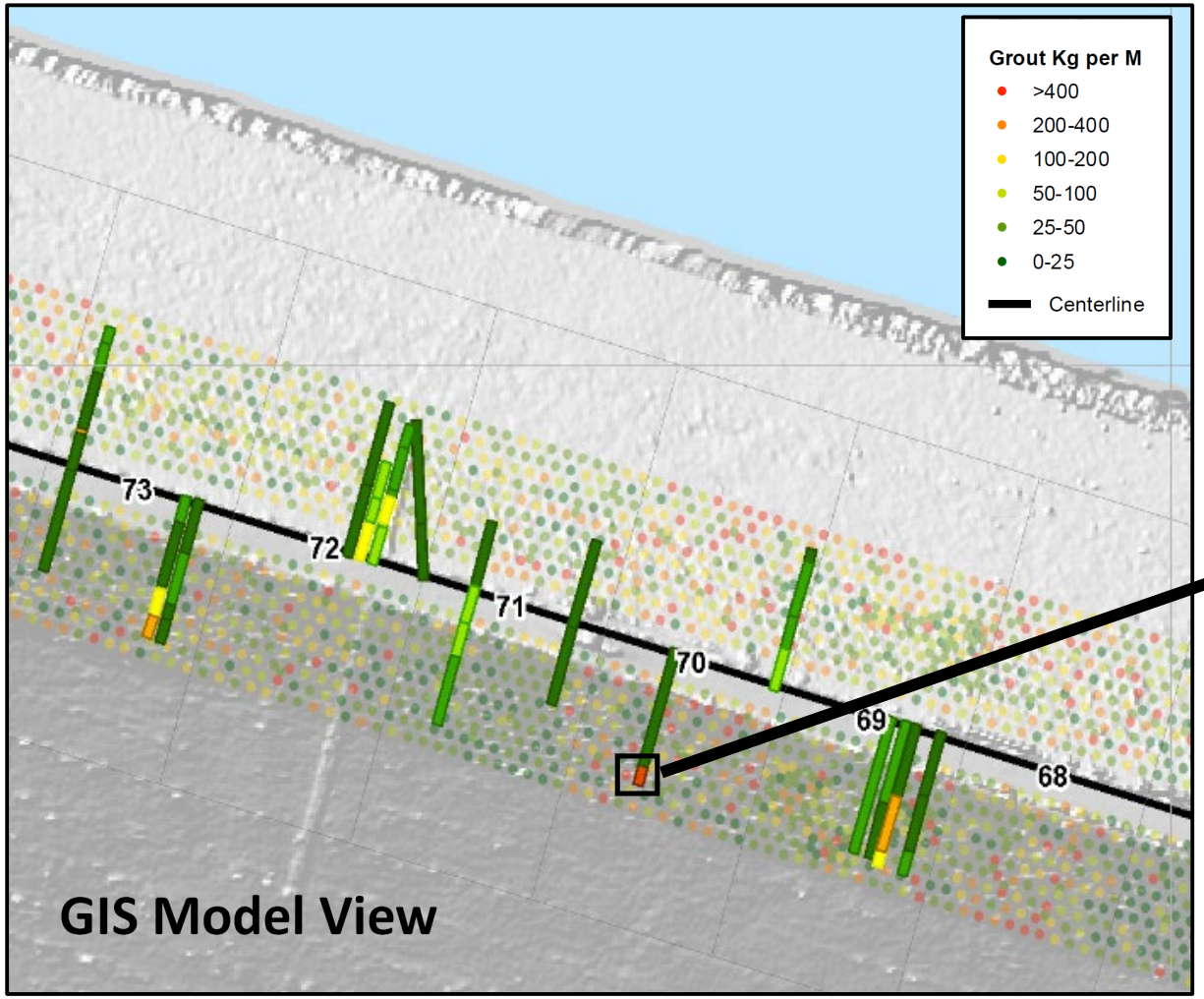
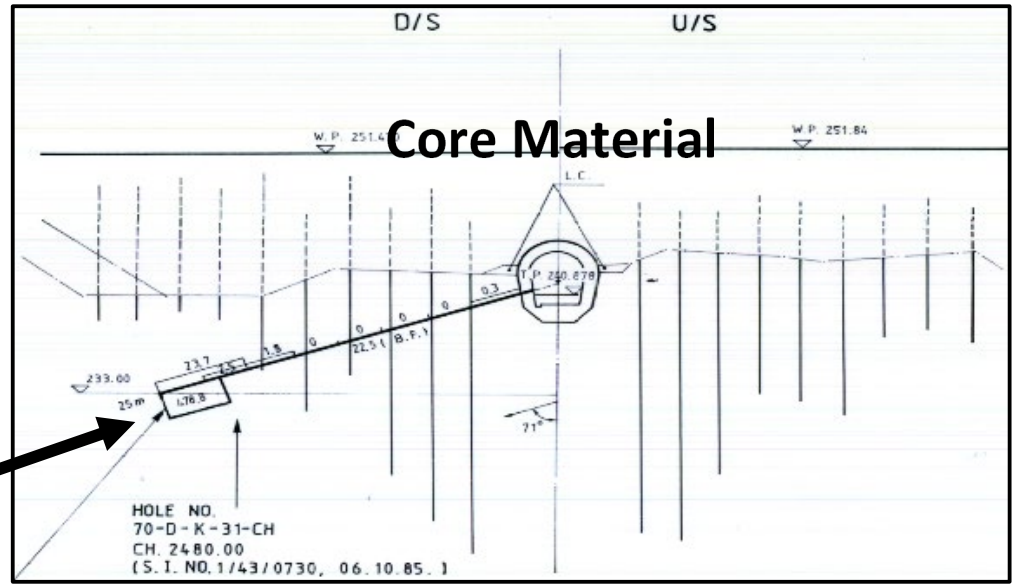


Hyperlinked Check Hole As-Built Document



Significant grout take in check hole below blanket grouted zone.

——— Blanket Grout Hole In-Place

------ Blanket Grout Hole Excavated

With a good data flow – we can do complex analysis and mapping

QUICKLY!

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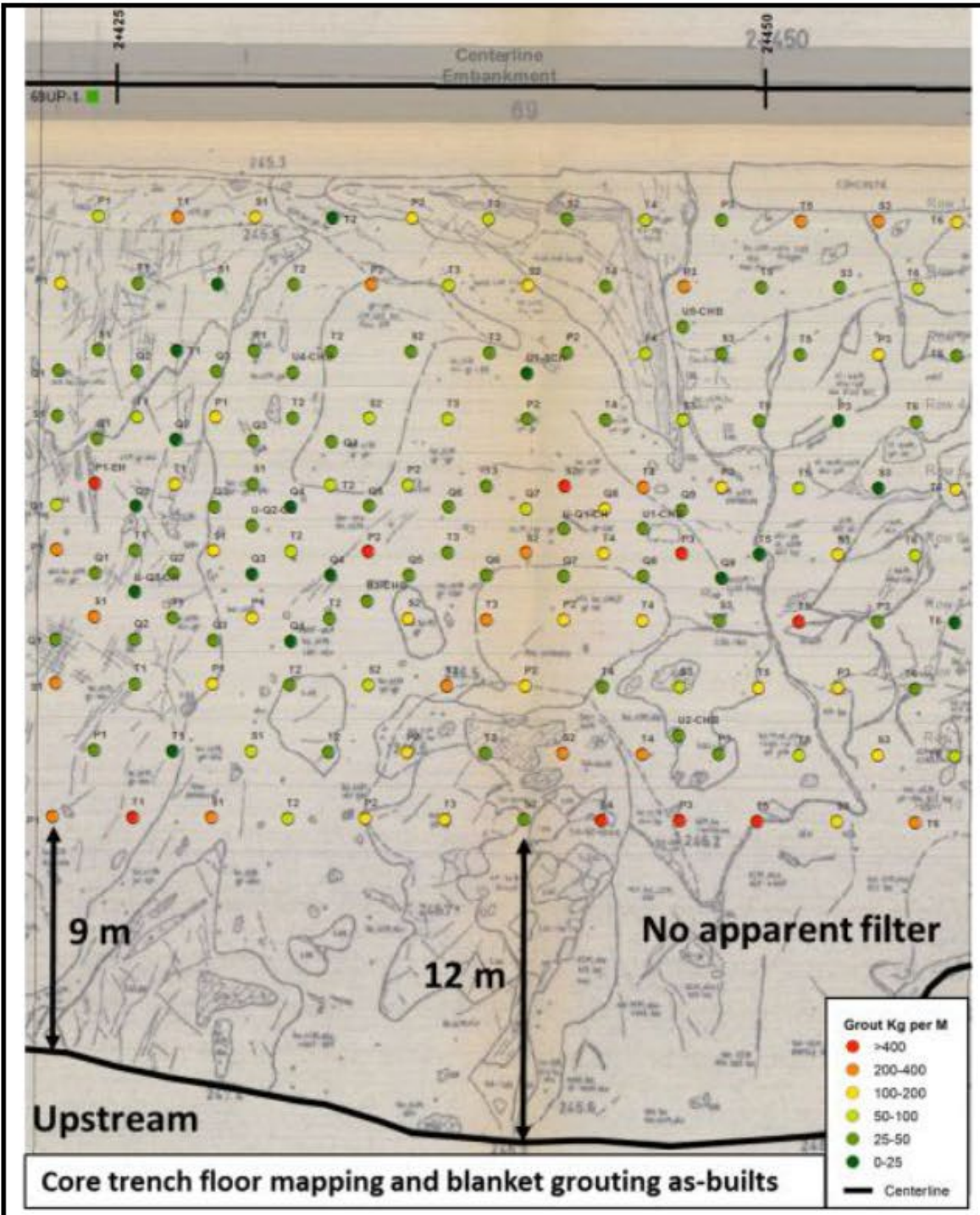
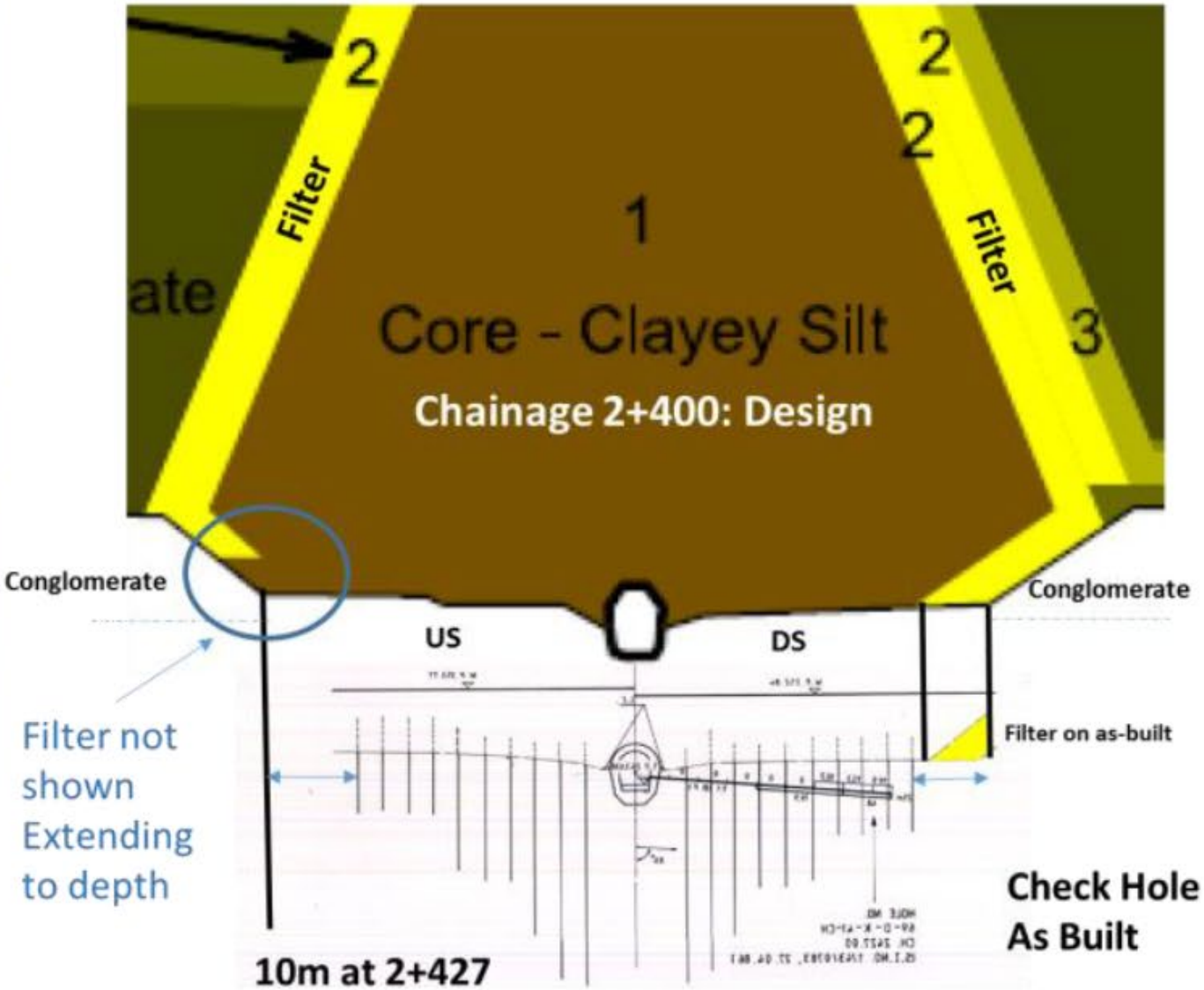


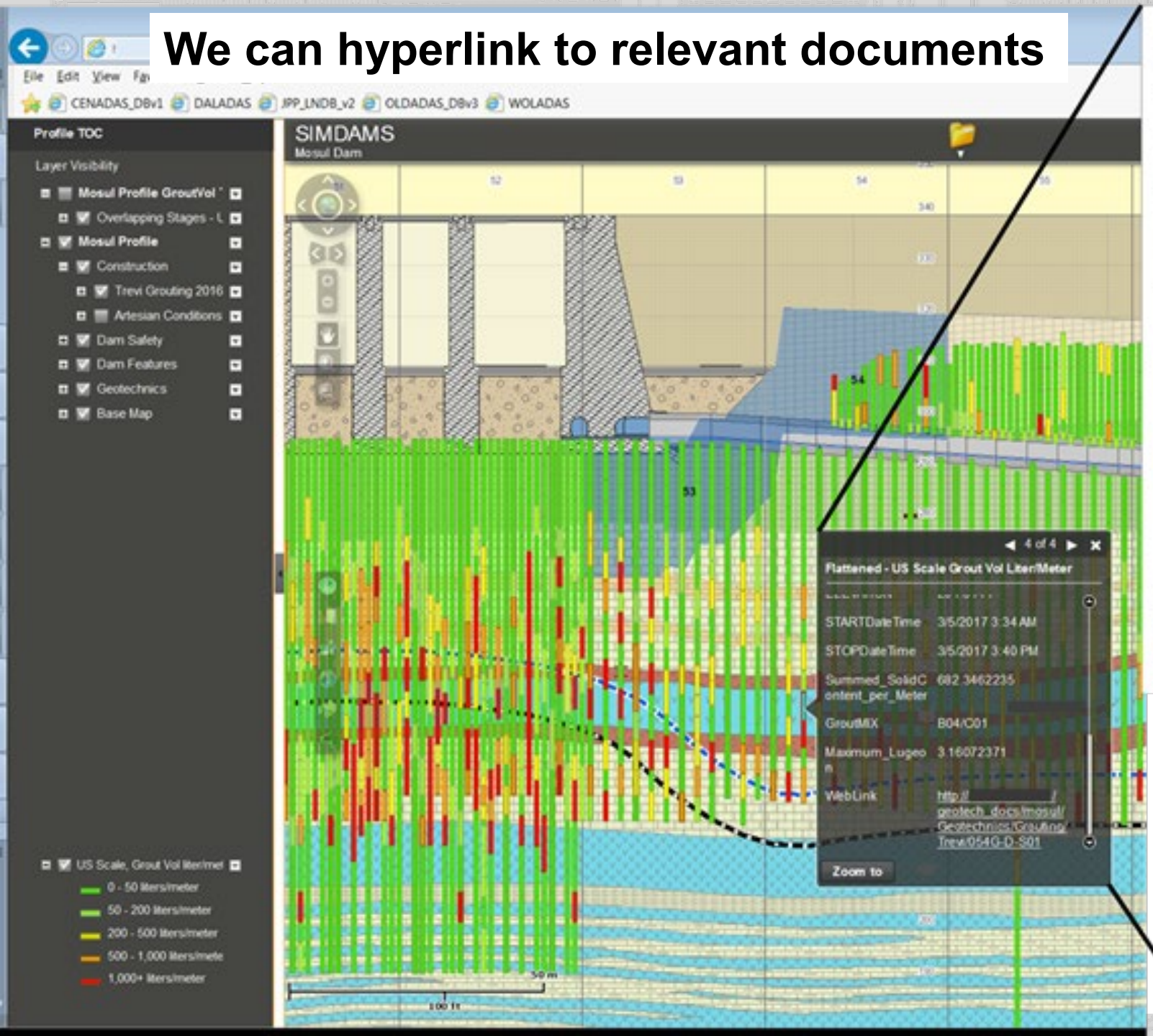
Core trench floor mapping and blanket grouting as-builts

Blanket Grouting Extent: Section 69

US of Dam – Core extends beyond blanket grouting zone.



We can hyperlink to relevant documents

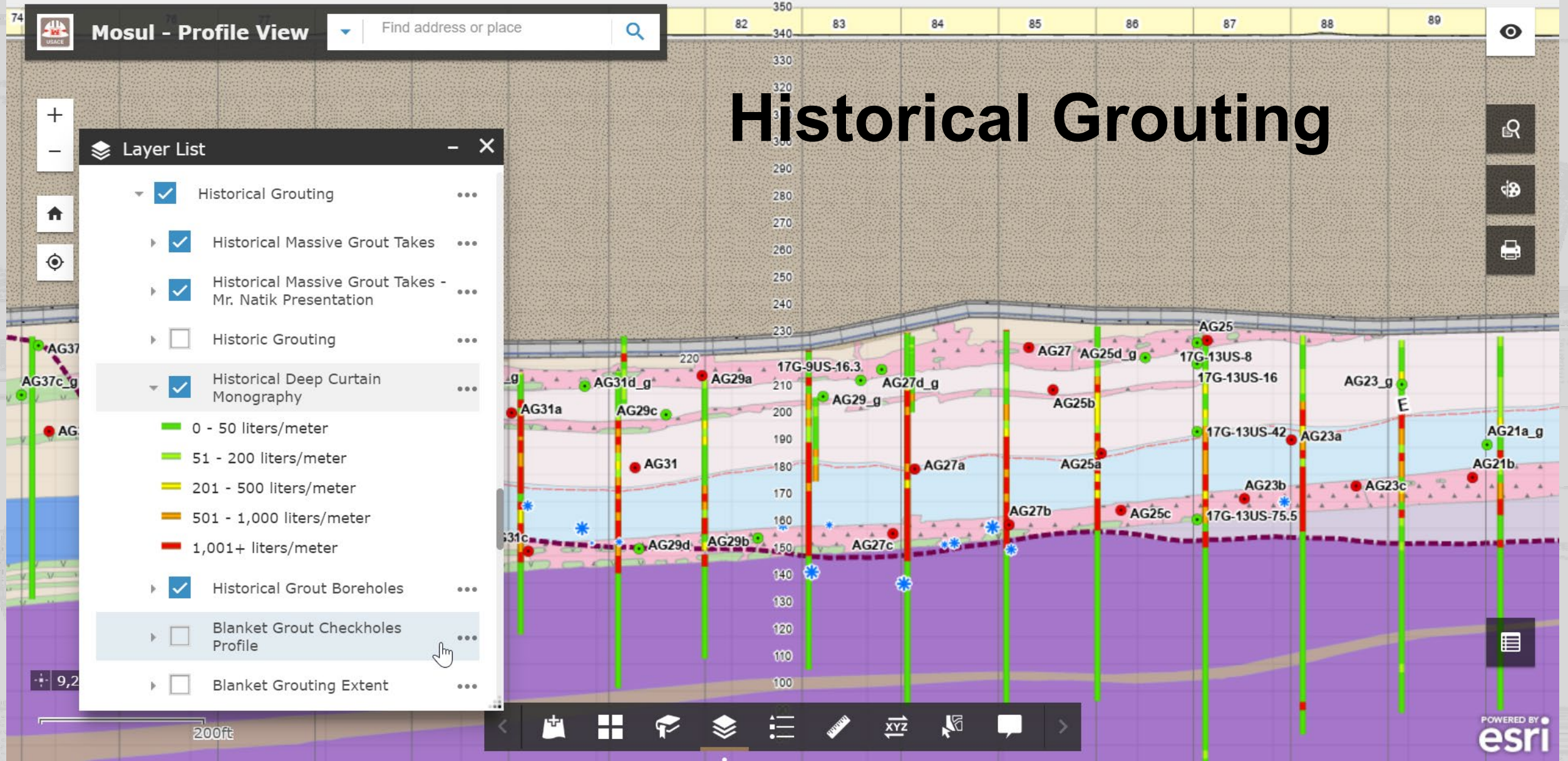


Mosul

Plan | Profile

And easily compare old data with new data

A Story Map

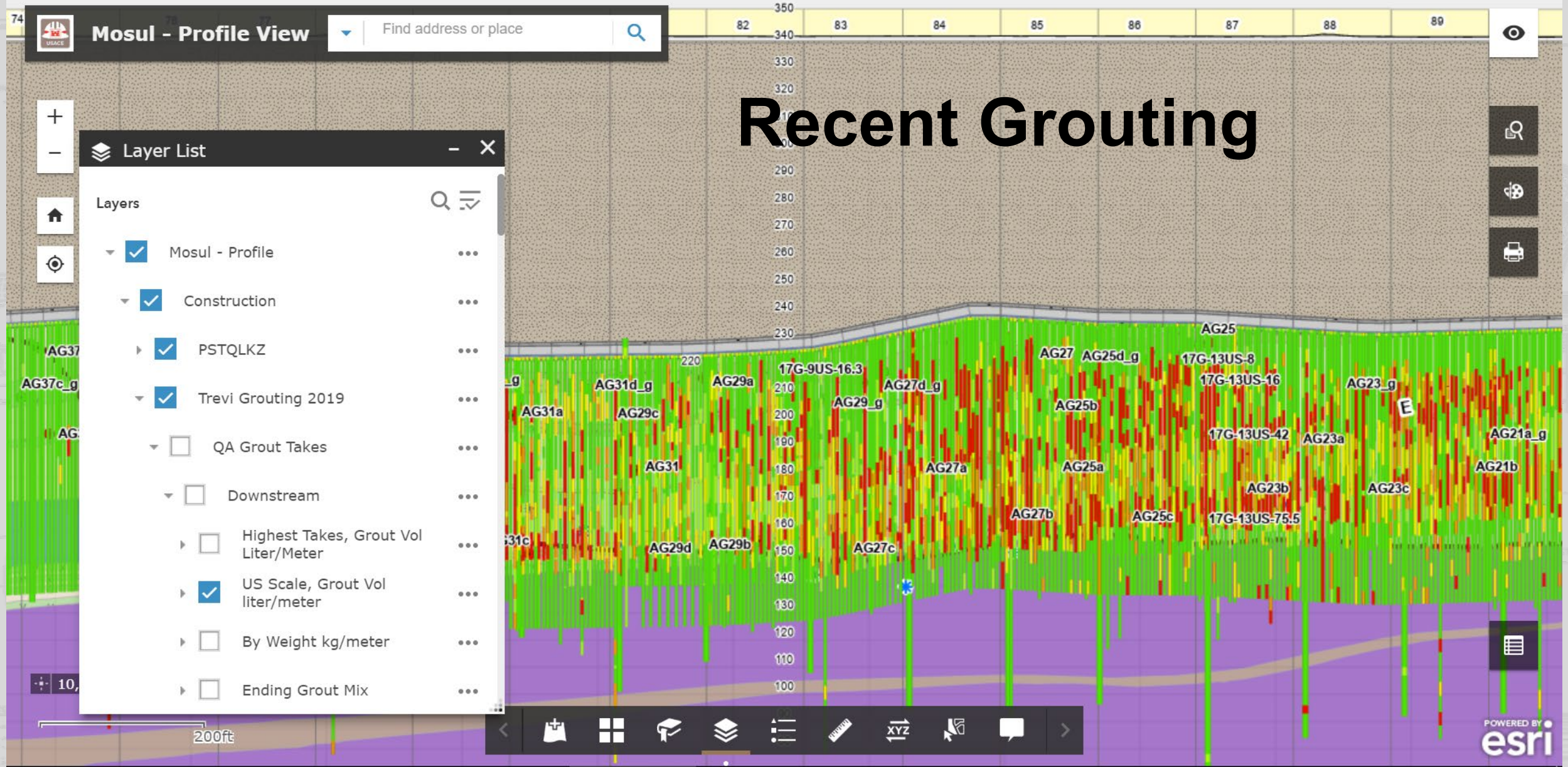


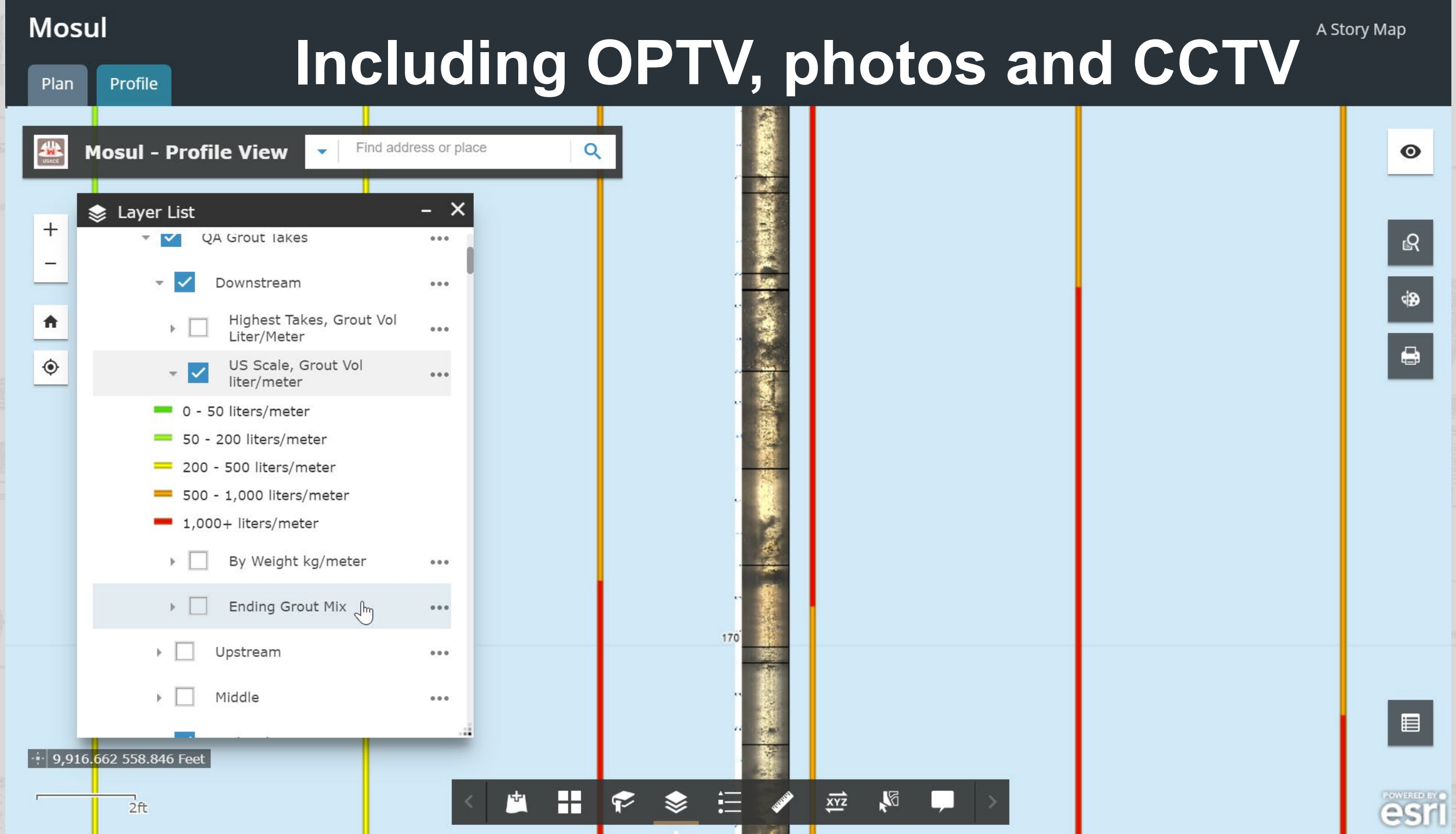
Mosul

A Story Map

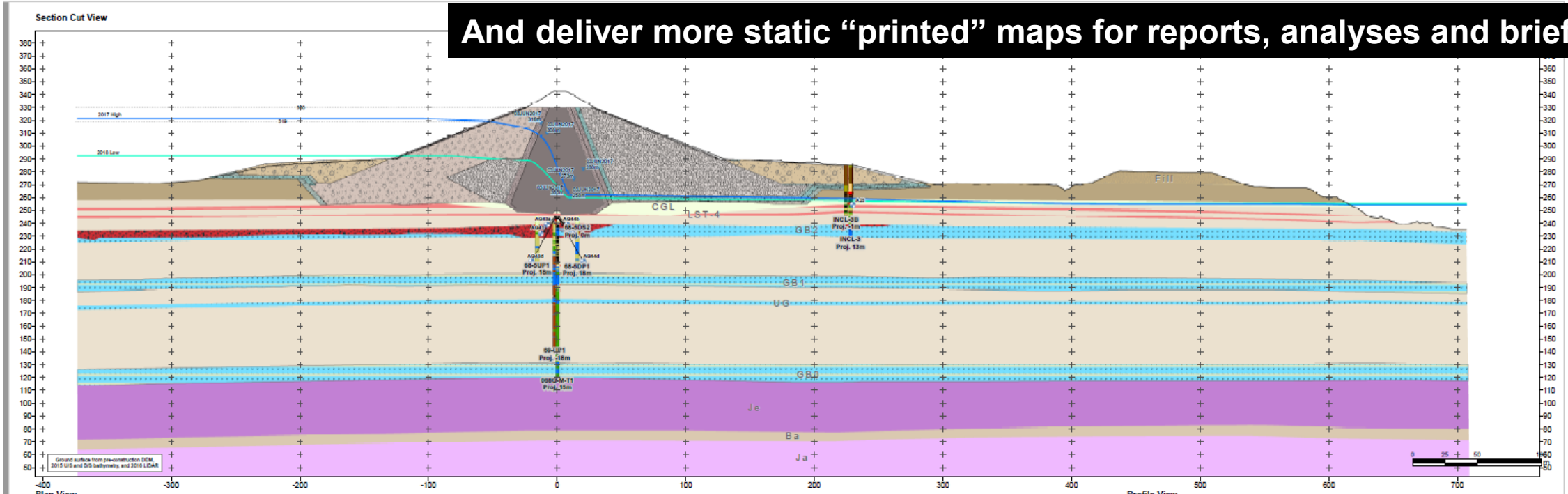
Plan | Profile

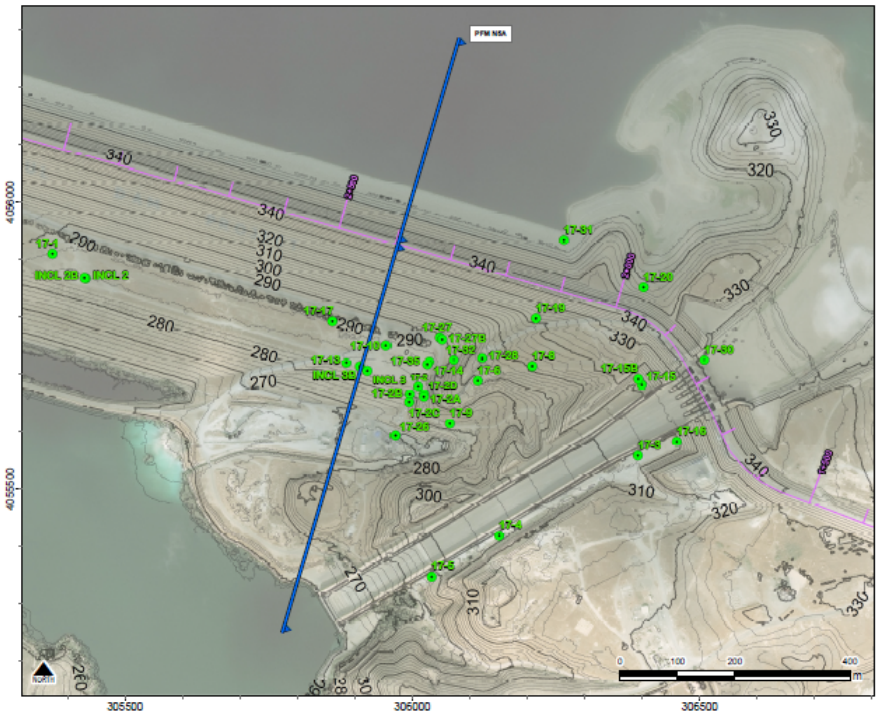
And easily compare old data with new data




Mosul
A Story Map
Plan
Profile
Including OPTV, photos and CCTV
Mosul - Profile View
Find address or place
Layer List
QA Grout Takes
Downstream
Highest Takes, Grout Vol Liter/Meter
US Scale, Grout Vol liter/meter
0 - 50 liters/meter
50 - 200 liters/meter
200 - 500 liters/meter
500 - 1,000 liters/meter
1,000+ liters/meter
By Weight kg/meter
Ending Grout Mix
Upstream
Middle
170
9,916.662 558.846 Feet
2ft
POWERED BY esri

And deliver more static “printed” maps for reports, analyses and briefings





Legend: Section Cut View (Above)

- Water Elevations
- Piezometers

OPTV Cavities

- CG - Cavity Filled with Grout
- CO - Cavity Open
- CP - Cavity Partially Open

Boreholes

Graphic

- (No Value)
- Marl, Upper Marl, Lower Marl, Clayey Marl, Decomposed Marl, Claystone
- Alluvium
- Anhydrite, Gypsum, Gypsum-Anhydrite
- Asphalt, Base Coarse, Concrete, Steel Liner, Steel Stiffener
- Brecciated Marl, Brecciated Clayey Marl
- CH, CL, CL-ML, CLG, CLS, ML, Lean Clay
- Conglomerate
- Cavity; Rod Drop (historical)
- Core Barrel Stuck; Core Loss; No Core Recovered; Not Cored (historical)
- Fill
- GC, GM, GP, GP-GC, GPS, GW, GWS, USCS5 GP, GW-GM, Silty Gravel with Sand
- Grout
- Limestone, Interbedded Limestone and Marl, Marly Limestone, Limestone + Gypsum, USGS 641, Dolomite, Decomposed Limestone
- Riprap
- Sandstone, Siltstone
- SC, SM, SP, SP-SC, SP-SM, SPG, SW, SW-SM, SWG
- Shale

Dam Elements (if shown)

- Clayey Silt
- Concrete
- Conglomerate
- Conglomerate or Processed Alluvium D
- Limestone
- Limestone Boulders
- Processed Alluvium
- Processed Alluvium B
- Processed Alluvium C
- Random Fill

sec_68_poly

Stratigraphy

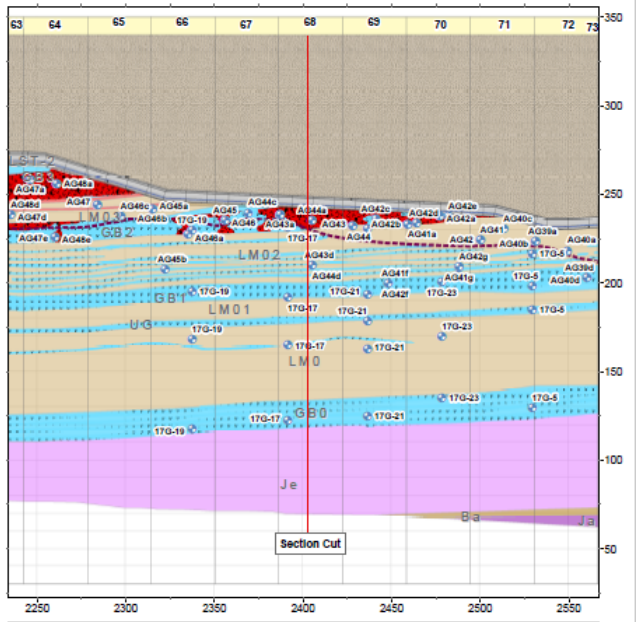
- Fill
- EMB; OB
- CGL
- UM
- F-Bed
- GB3; GB2; GB1; UG; UG3; GB0
- LM04; LM03; LM02; LM01; LM0
- LST-1; LST-2
- LST-3; LST-4
- Ja
- Ba
- Je
- Estimated PZ High 2017
- Estimated PZ Low 2018

Legend: Plan View (Left)

- Cut: 68
- Exploratory Holes

Legend: Profile View (Right)

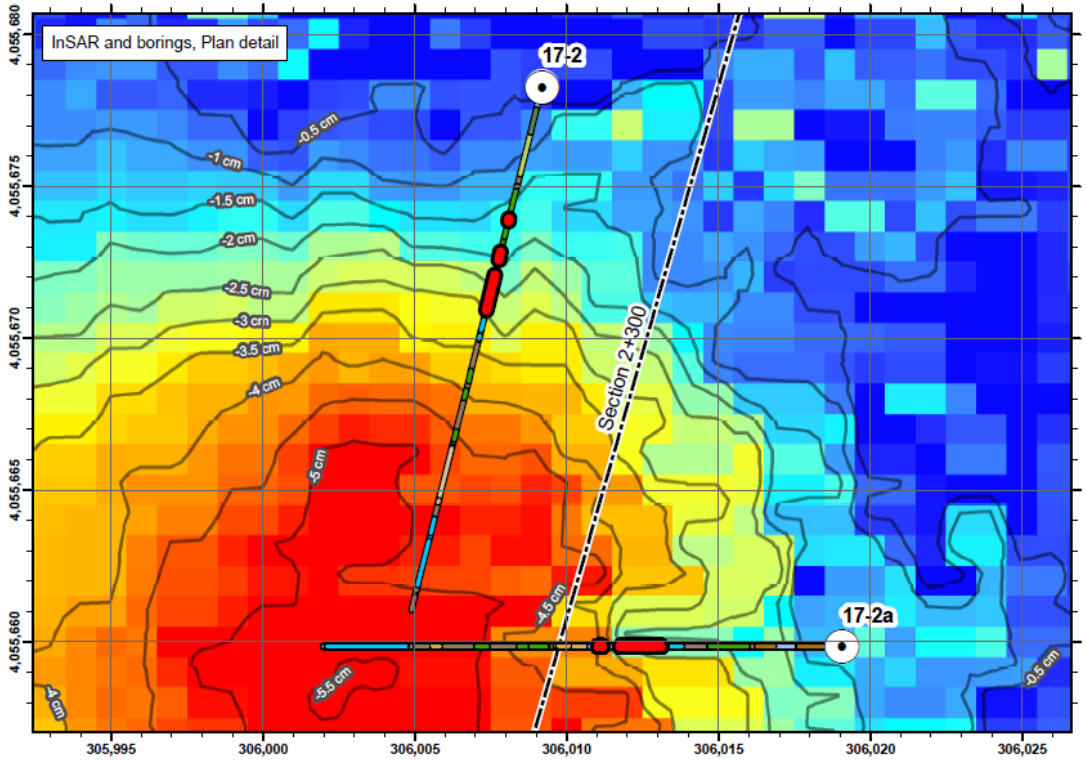
- Piezometers (All)
- OB
- UM
- F-Bed
- LM0; LM02; LM03; LM04; LM01
- LST-1; LST-2
- LST-3; LST-4
- GB0; GB1; GB2; GB3; UG
- Je
- Ba
- Ja

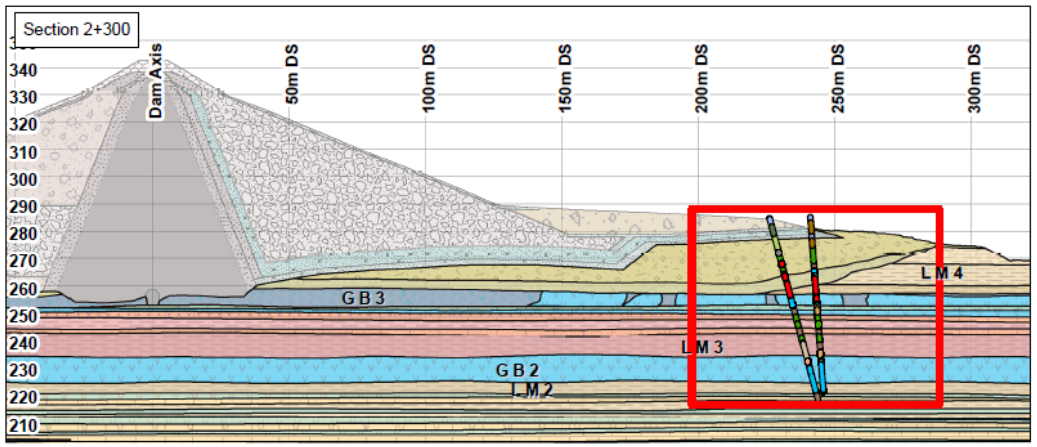


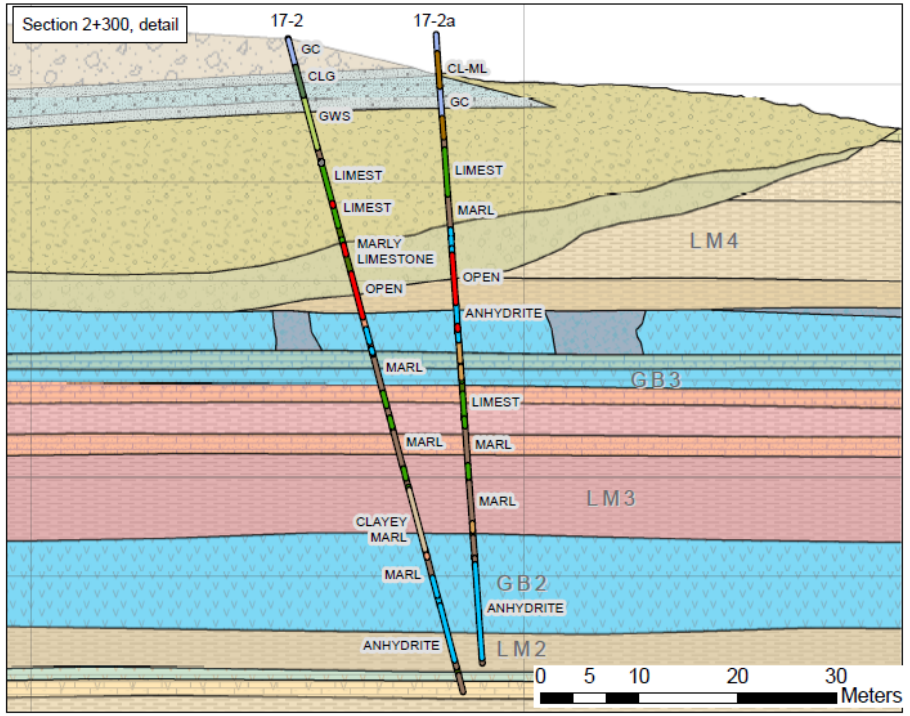
Mosul Dam Geologic Section 68 DRAFT
2+400 PFM N5A

Mosul Dam Task Force
Map Produced 4/20/2018

Mosul, Groin Depression Investigation







Data Sources:
InSAR: Neva Ridge results from 08-22-2015 to 08-17-2017

N

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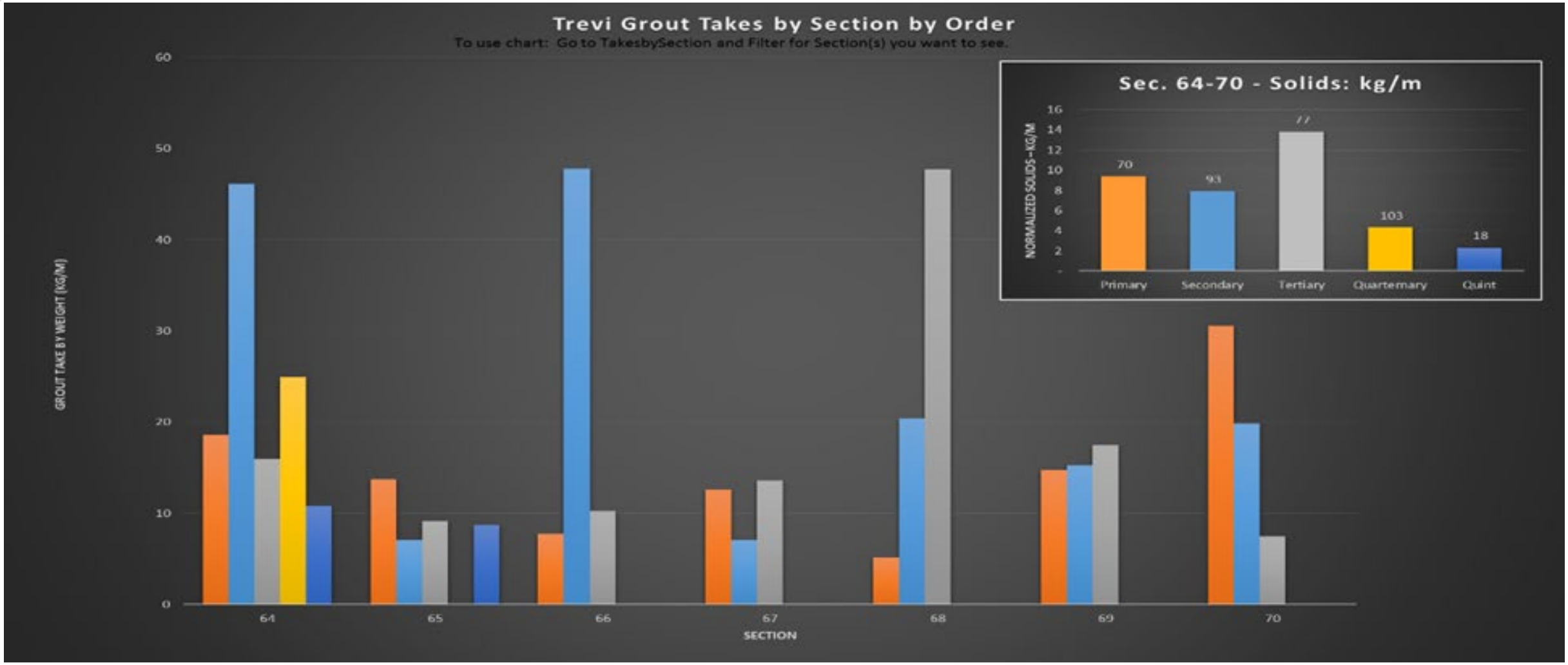

We can easily link and automate graphs!

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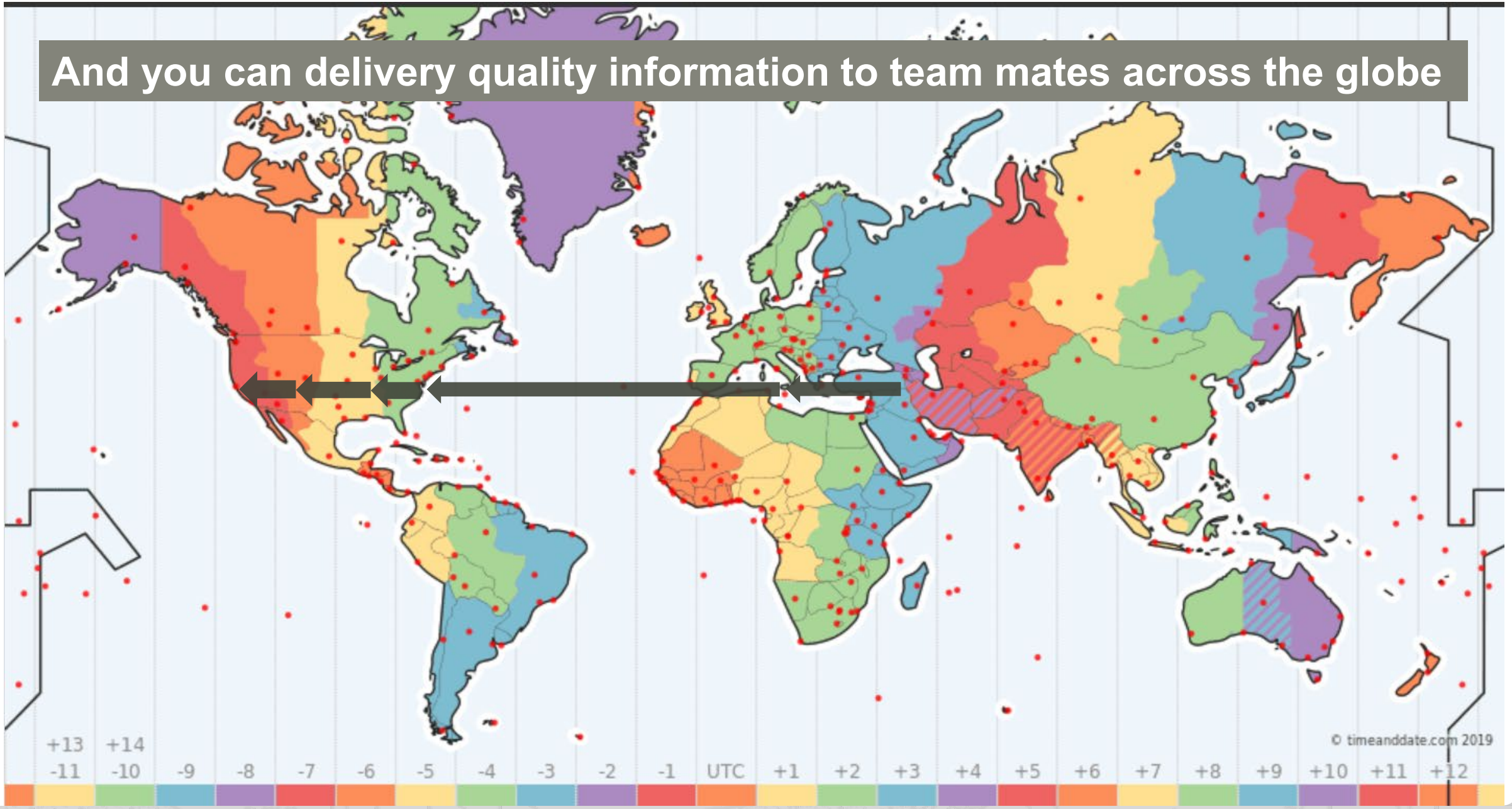
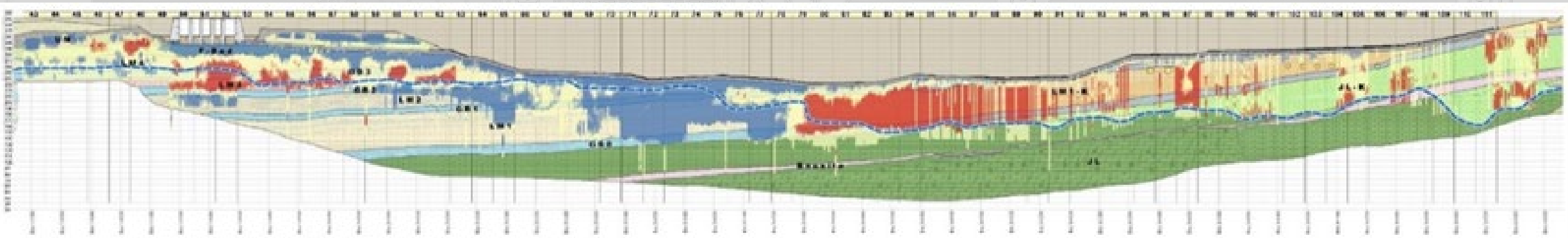

And you can delivery quality information to team mates across the globe
+13 +14
-11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 UTC +1 +2 +3 +4 +5 +6 +7 +8 +9 +10 +11 +12
© timeanddate.com 2019



Hot Spot Analysis (Getis-Ord Gi*)

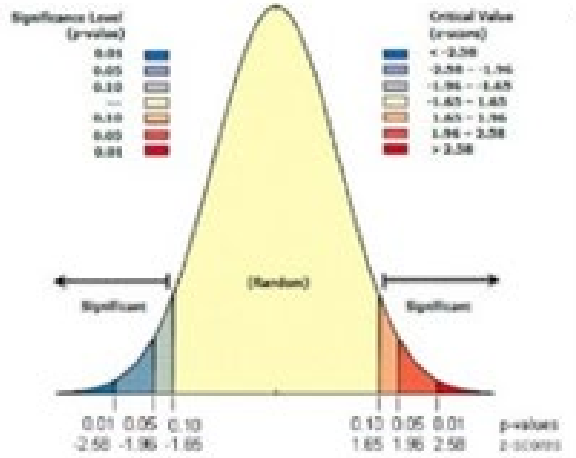
Determines spatially statistically significant regions of high grout values

Given a set of weighted features, identifies statistically significant hot spots and cold spots using the Getis-Ord Gi statistic*

Grouting_AECOM_Profile_Hot_Spot_Log

Gi_Bin

- Cold Spot - 99% Confidence
- Cold Spot - 95% Confidence
- Cold Spot - 90% Confidence
- Not Significant
- Hot Spot - 90% Confidence
- Hot Spot - 95% Confidence
- Hot Spot - 99% Confidence
- Original Construction Permeability Line



We can also leverage geospatial analyses

… and now we have a potential data set for testing machine learning

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ORGANIZE

Consolidate a variety of borehole data into a simple file structure

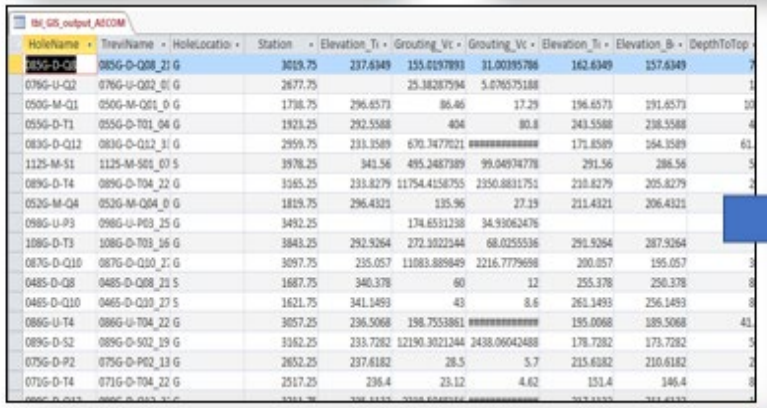
VISUALIZE

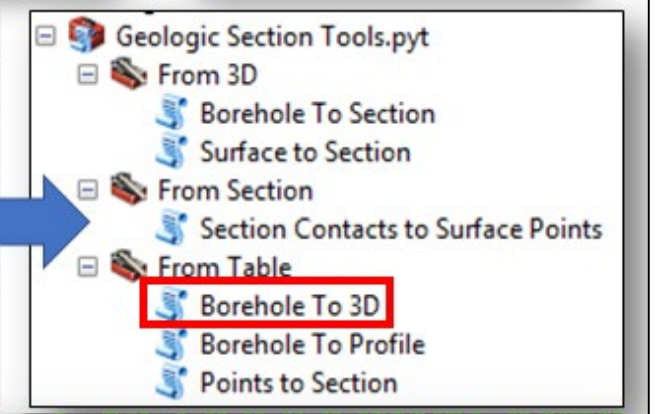
Create 2D and 3D GIS features from large databases

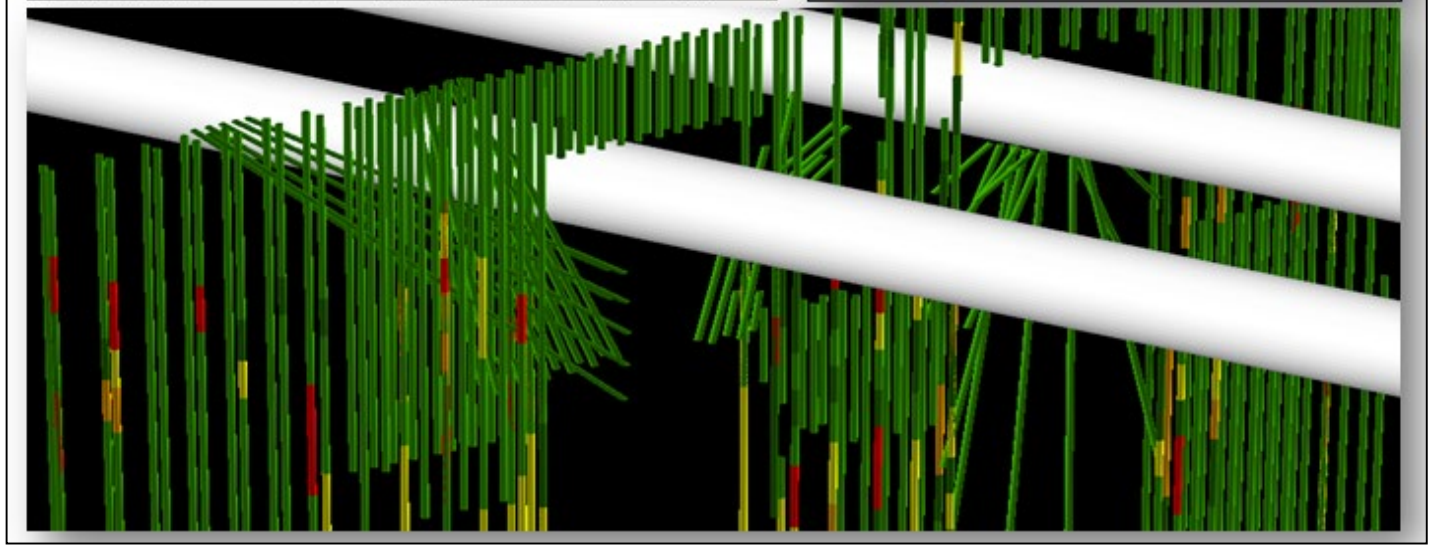
Quickly generate PZ plots for numerous projects simultaneously

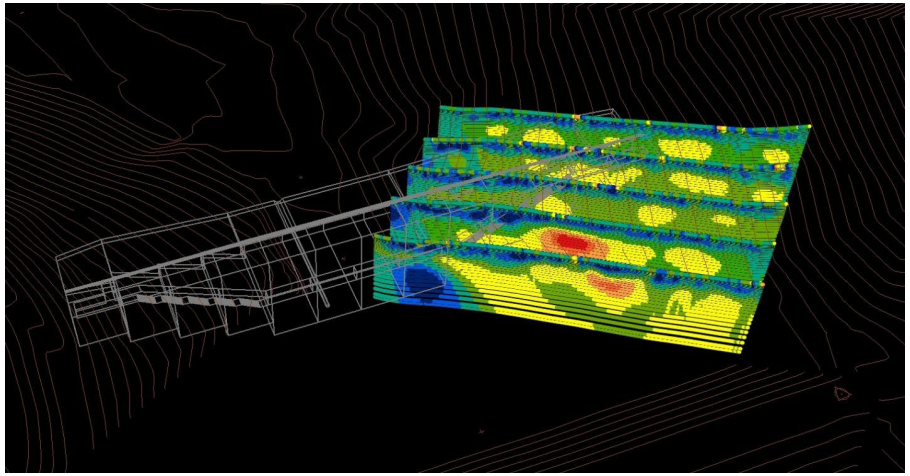
ANALYZE

Identify potential hydraulic fracturing in grouting time series data









Get our existing work out of the flat 2D monitor and into 3D space

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Center Hill Models

BUT – We MUST Plan for HOW the data need to be used

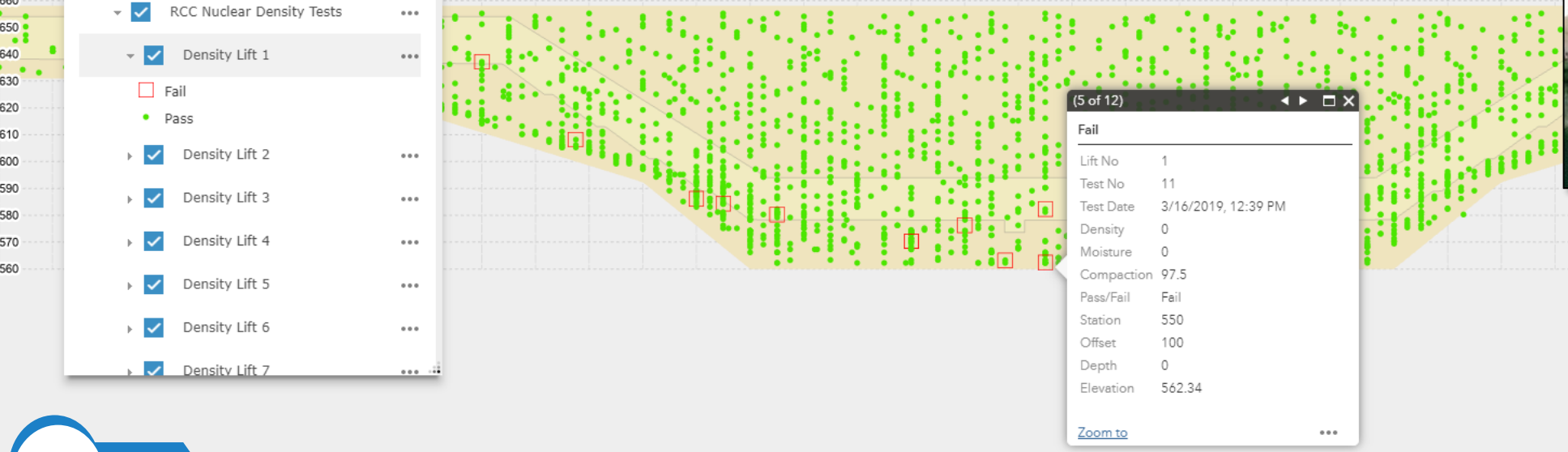
CEN RCC - Plan | CEN RCC - Profile | CEN - Plan | CEN - Profile

CEN RCC - Profile LRN

Find address or place

Layer List

- 03 37 23 CONCRETE
  - Concrete Property Test Locations - Planned
  - RCC Nuclear Density Tests
    - Density Lift 1
      - Fail
      - Pass
    - Density Lift 2
    - Density Lift 3
    - Density Lift 4
    - Density Lift 5
    - Density Lift 6
    - Density Lift 7



(5 of 12)

Fail

Lift No	1
Test No	11
Test Date	3/16/2019, 12:39 PM
Density	0
Moisture	0
Compaction	97.5
Pass/Fail	Fail
Station	550
Offset	100
Depth	0
Elevation	562.34

Zoom to

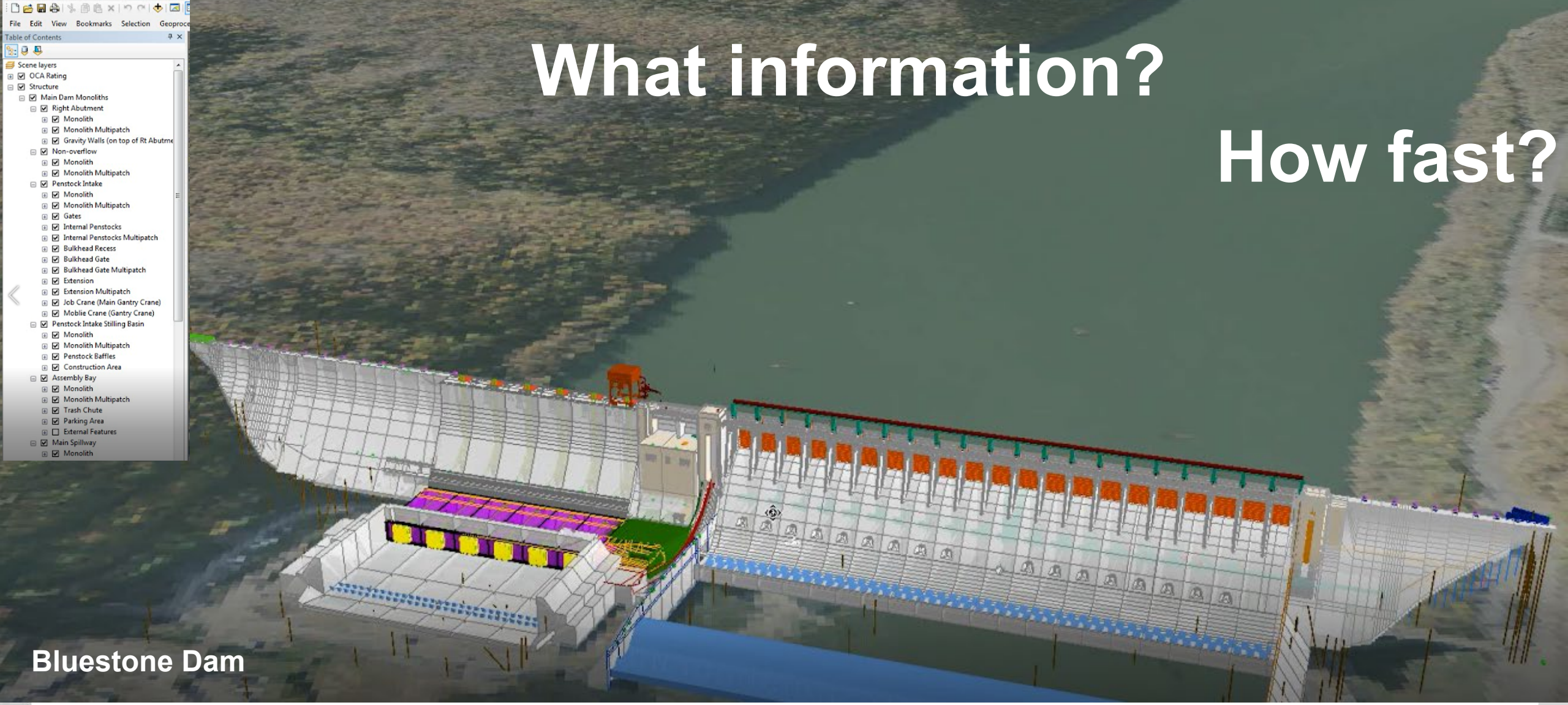
What VALUE does the information bring to the team?

769.239 516.744 Feet

40ft

Powered by esri

Center Hill Dam – Roller Compacted Concrete Density Test Distribution



Fully 3D Data Management Models

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6 Days after this we had our Post Construction Risk Assessment

Some Lessons Learned

1. You need a DATA MANAGEMENT System – Not just a database
2. Data must be accessible at the “speed of relevance”
3. Paper and files are not enough any more
4. Use the database to distribute data to the right people
5. KEEP YOUR DATA ORGANIZED – Digital chaos happens quickly
6. Talk to people who have done it before!

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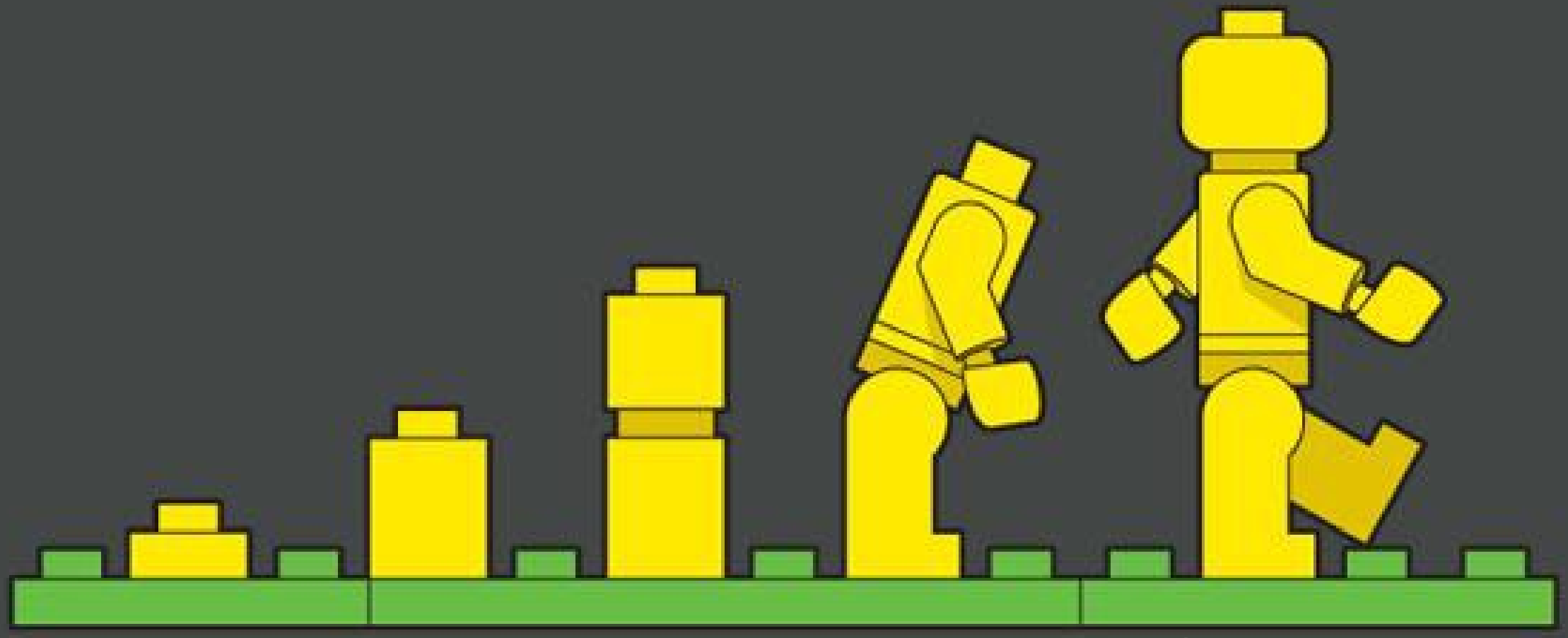
7. EXPECT!!! To Change with Technology



Plumb Bob
& Paper

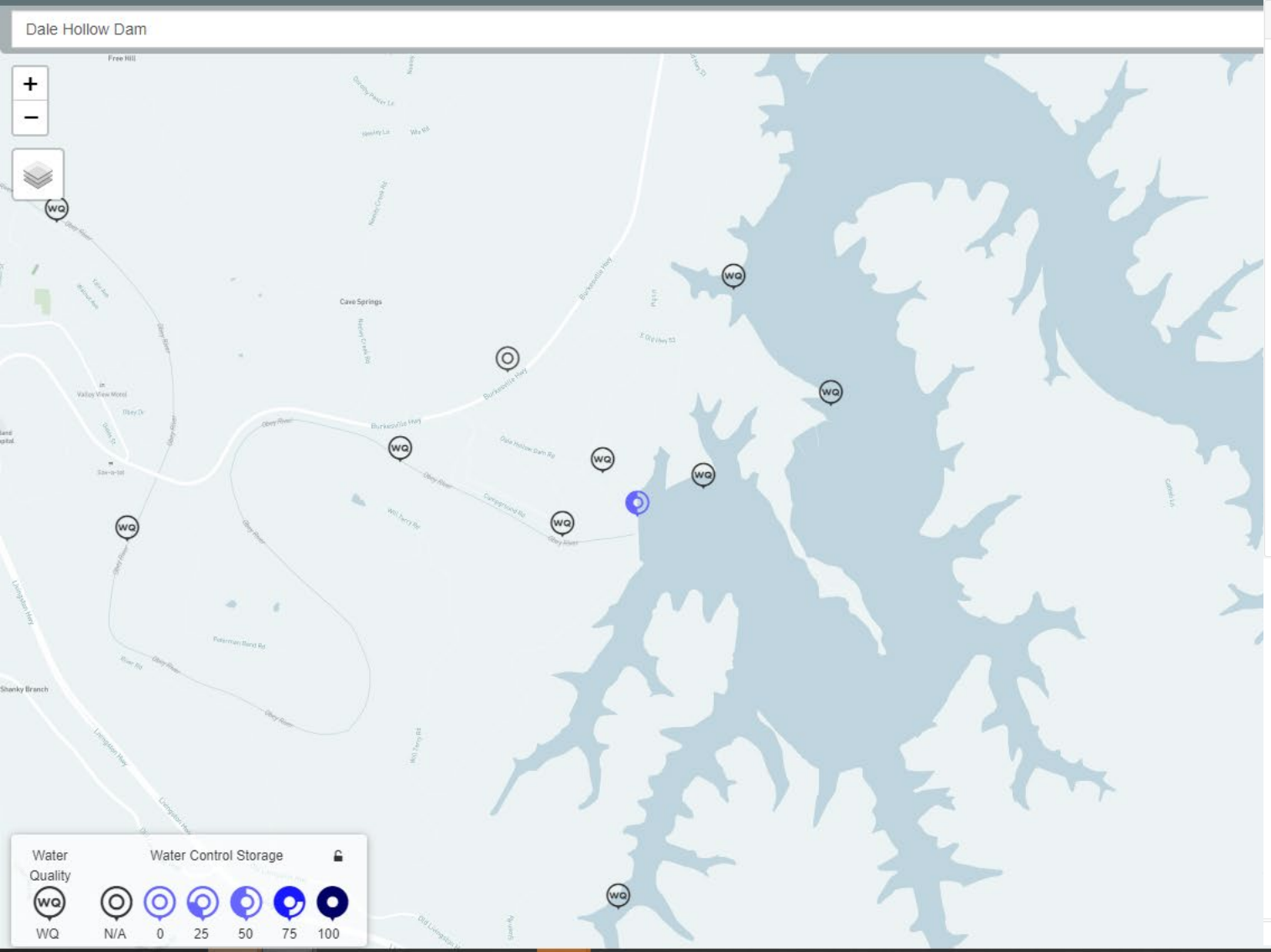
Satellite Imagery
Smart Phones
Databases & GIS
Automation!

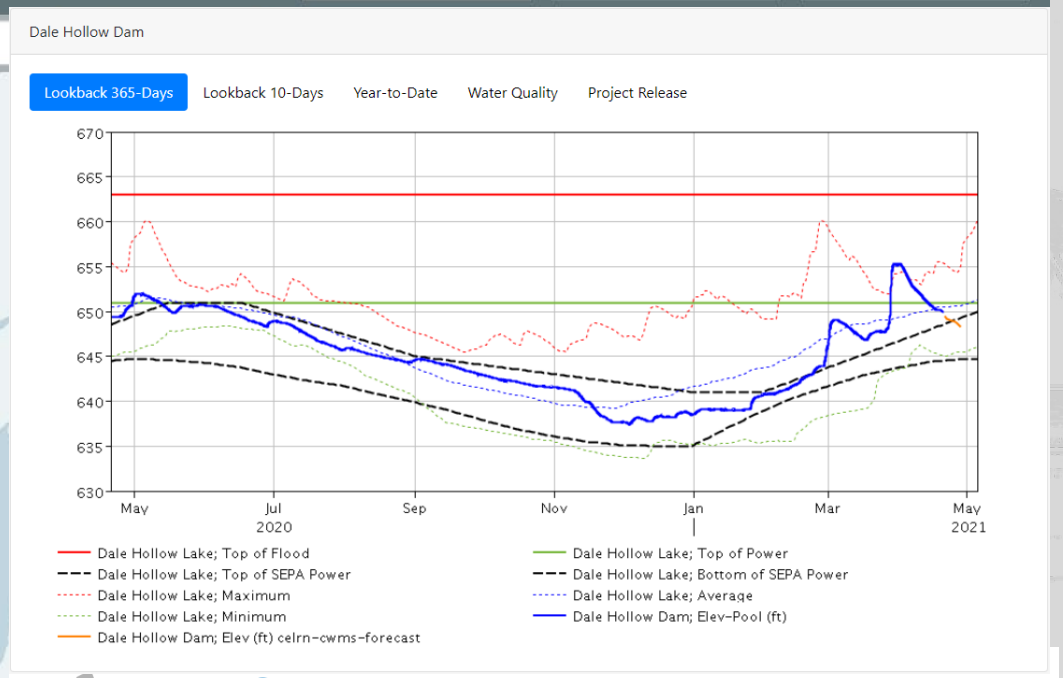
8. People are going to expect more.

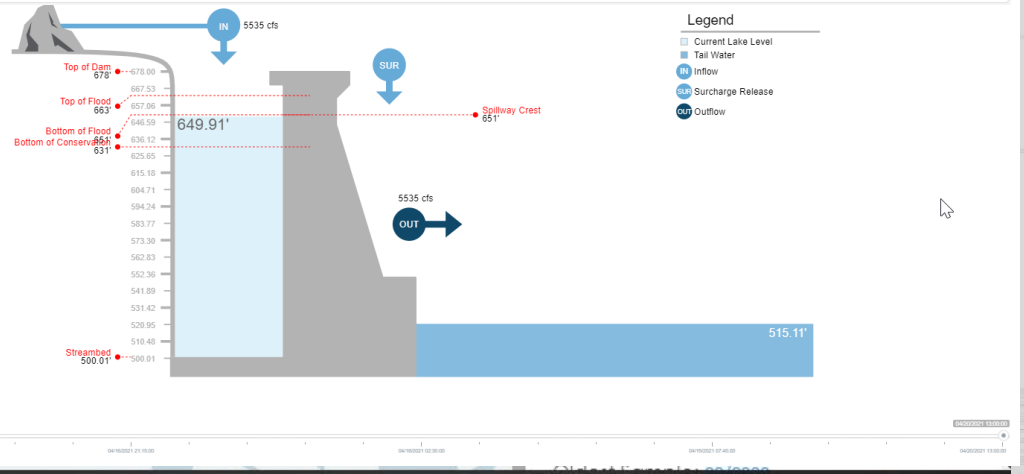
Access to Water Resources Data
WM Data Dissemination

Dashboards and Data Analytics are the Standard

Map | Overview | Help







9. Treat data as a shared asset and resource

10. NEVER NEVER NEVER enter data more than once if avoidable

11. Manage the data or it WILL manage you – you need a data management plan

12. Data analysis and data gathering are not the same.

13. Data analysis WILL reveal unknows

14. Monitoring frequency matters

15. Use software that has sharable data

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16. NEVER let the perfect be the enemy of the good!

Questions?